VOLUME 68 [W. B. No. 1290] NUMBER 3

MONTHLY WEATHER REVIEW

MARCH 1940

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UNITED STATES DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

WASHINGTON, D. C.

1940

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MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 68, No. 3
W. B. No. 1290

MARCH 1940

CLOSED MAY 3, 1940
ISSUED JUNE 24, 1940

ON THE DISTORTION OF STREAM FIELDS BY SMALL HEAT SOURCES

By J. J. GEORGE

[Eastern Air Lines, Hapeville, Ga., May 1939]

The effect of comparatively small heat sources on cold currents has attracted little attention. Most writers confine themselves to mentioning that such heat sources produce instability and perhaps squalls in the area which lies in the "shadow" of the heat source. Such a problem is of considerable importance in forecasting, and several complications not generally recognized are introduced.

The problem was called to the writer's attention by H. T. Harrison [1] in a paper investigating terminal conditions at Chicago and Cleveland airports. Each of these airports is adjacent to the Great Lakes, and these lakes at certain times of the year and with appropriate conditions serve as heat sources such as we have under consideration. Harrison mentioned in his paper a frontal effect observed at both stations which did not seem to move with the gradient wind, but rather appeared almost stationary. The front produced moderate snow and was characterized by a change in wind direction as well as in temperature and humidity.

In an effort to arrive at a logical explanation of the observed phenomena, it will be necessary first to make certain simplifying assumptions and later apply empirical corrections. Elliott [2] has shown how discontinuities are formed over the heat source of the Florida Peninsula. Although not entirely dissimilar, there are significant differences in the two problems. In Florida, motion begins from a condition approximating rest and proceeds freely to an equilibrium of sorts. In the problem considered here, cold air initially in motion passes over the heat source, and equilibrium is not reached—at least, not over the heat source.

Referring to figure 1a, the heat source is designated by the heavy solid lines forming a square. It is assumed that the heat source is a lake of comparatively warm water 200 miles on each side. A cold (with reference to the lake water) horizontally homogeneous current is flowing toward the lake with a gradient velocity U_0.

It should be remarked here, that the instability produced by the lake is directly dependent on U_0, since, if a certain critical value is reached which depends upon initial temperature conditions, it is obvious that the air could pass over the lake without allowing time for sufficient heating to produce the characteristic squalls, and further that the degree of heating is a function of the time spent in crossing the lake. U_0 is taken as 30 m. p. h. for purposes of computation in this paper. Dry adiabatic lapse rates are assumed throughout the layers concerned. This assumption does not differ greatly from actual conditions, since Rossby and Montgomery [3] have shown that a lapse rate approximating the dry adiabatic will be established up to about 1 km. in a current of this magnitude with the character of terrain assumed to surround most lakes. The action of the warm source will be to lift the inversion at the top of the turbulent layer from about 1 km. above the surface to about 2½ km. This last value is deduced from reports of the top of the instability cloud decks in the lee of the Great Lakes.

This means that the layer originally 1 km. thick has been increased 2½ times during the passage of 200 miles. It is important to know if the original turbulence inversion was strong enough to limit convection and hence if the additional air was supplied from the sides of the lake. If the heating across the lake is 15° F., the turbulence inversion must be about the same if it is to limit the convection. A more nearly normal value of the turbulence inversion would be 4° F. Further, a short calculation is sufficient to show that the order of magnitude of the wind from each shore toward the lake would have to be about an average of 20 m. p. h., assuming the inflow to occur through the lower 500 meters. No velocities at all comparable to this are observed in practical cases, so it must be concluded that convection takes in more and more air into the lower layer from above. Since this layer becomes thicker as it advances over the lake, there is more air to heat as it progresses, and, in addition, the air more nearly approaches the lake surface temperature. For these reasons the isotherms shown as dashed lines in figure 1, show the most rapid rise in temperature of the layer to be near the windward shore. Ideally, a mathematical temperature discontinuity would be formed at the lake sides (AB and DC in fig. 1a), but horizontal lateral mixing modifies it somewhat and the isotherms have indicated a close approach to the actual condition with a zone of transition.

The short, heavy arrows represent the surface wind. It is assumed that the angle between the surface wind and the gradient wind is 25° over the land surface and that this angle decreases to 18° over the lake. These figures are obtained from the work of Rossby and Montgomery,[4] and correspond respectively to an average obstruction of about 16 meters over land and 30 cm. over water. It is further considered that due to this same effect of decrease of surface friction, that the winds in the surface layers over the lake must be increased something on the order of 20 percent. In this way, any area of suddenly increased or decreased surface friction acts as a refraction device to surface winds. Further, an increase of friction has the effect of piling up air along the boundary of the increase. If stable air is considered, the refraction will be intensified although the absolute velocities will be lowered.

In addition to this effect, Brunt [5] has pointed out that in a condition of this kind, the warmed air would be subjected to an increase in velocity proportional to the decrease in density. If we assume the total heating of the layer to

[1] H. T. Harrison, Terminal Weather Conditions on the Newark-Chicago Airway. United Air Lines Publication.

[2] R. D. Elliott, Land and Sea Breezes in Florida, (Not published.)

[3] C. G. Rossby and R. B. Montgomery, The Layer of Frictional Influence in Wind and Ocean Currents. vol. III, 3, Papers in Phys. Ocean. M. I. T. and Woods Hole Ocean. Inst.

[4] Loc. cit. fig. 8.

[5] D. Brunt, Physical and Dynamical Meteorology, 1st ed., p. 177.

be 15° F., between shores, then this factor will amount to an increase in velocity not only of surface, but of gradient wind of the order of 3 percent. These increases in velocity cause an increase in the Coriolis Force, which tends to deflect the current farther to the right over the lake. Left and right are used throughout with the observer facing downwind. It will presently be seen that this deviation is of little significance above, say, 1 km., but for the surface layers it is of definite importance. In this way, decreased surface friction produces immediate convergence along the right hand bank at very low levels.

Figure 1b shows a longitudinal section along the center line of the lake. Notice that the most rapid rise in the dome occurs near the windward shore and that the maximum height occurs over the lee shore, since the heating process is cumulative.

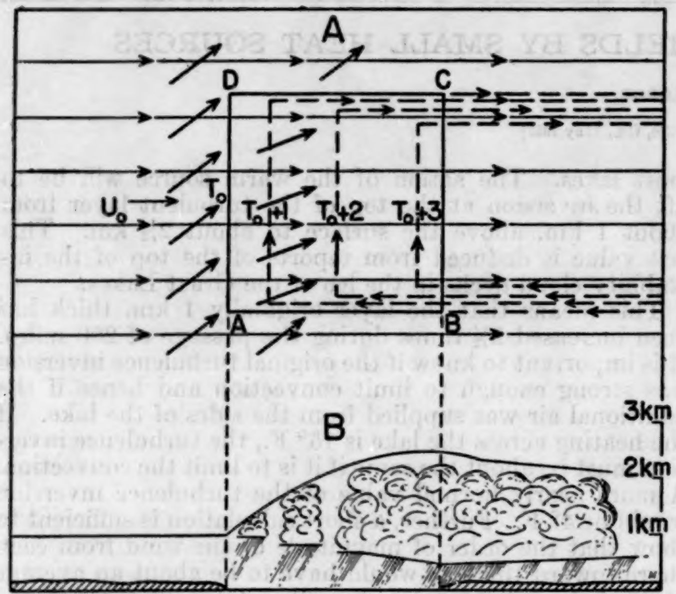

Figure 1.

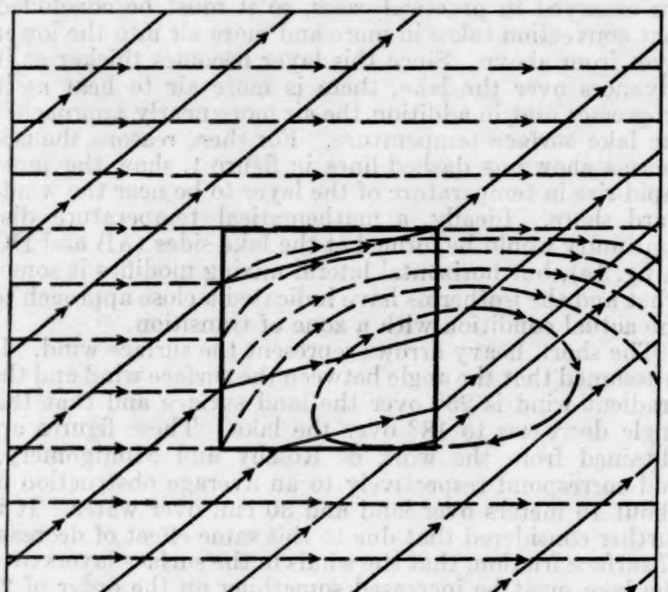
Figure 2.

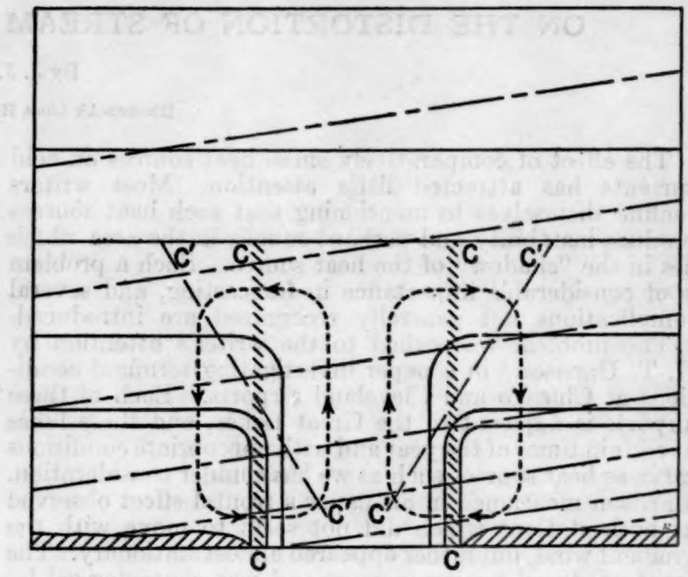

Figure 3.

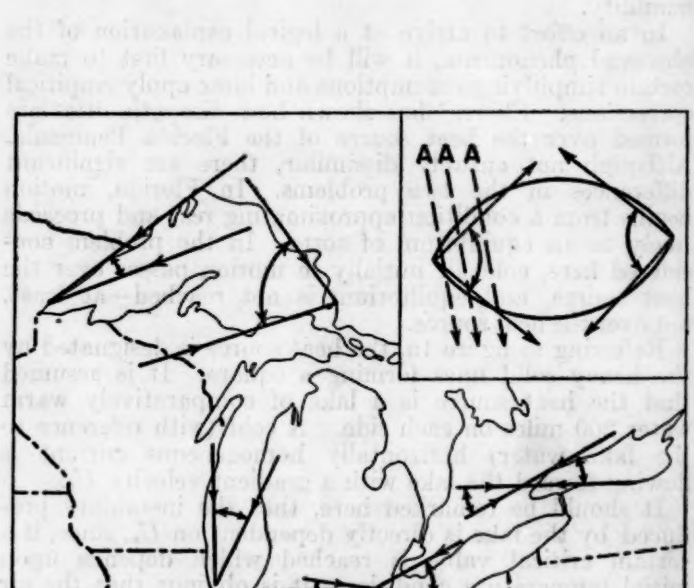

Figure 4.

It has been shown that the wind aloft at any level z, is closely approximated by the vector addition of the gradient wind and the thermal wind. This latter component is considered to blow around low temperature in the same sense that the barometric wind does around low pressure, i. e., always tangential to the mean isotherms and of a magnitude proportional to the temperature gradient and to z. Heating of 15° F. across the lake produces a thermal component on the order of 50 m . p. h. directed to the left. Along the lake sides, the thermal component increases with the creation of new isotherms reaching a maximum at the lee shore. This component is several times the magnitude of the gradient flow, and if no other factor were operating, would produce an actual reversal of flow along the right shore at higher levels and an enormous increase in the flow on the left shore.

Figure 2 shows the stream lines formed under the conditions postulated above, but with frictional drag being considered only in the lower layers. The solid lines are the stream lines of surface flow, and the dashed lines represent the flow near the top of the convective layer. Note that an anti-cyclonic eddy has been established in the upper level, and that results so far, point to a marked speeding up of air flow in the left side of the lake aloft and a reversal of flow on the right side. The refraction effect in the surface layers shows clearly in the surface stream lines. It should be noted here for later reference, that greatly increased values of the surface wind should be found on the right hand portion of the lee shores of lakes with subnormal velocities above.

Figure 3 shows a cross section transverse to the main current after a part of the lake has been traversed. The solid lines are lines of equal potential temperature which may be substituted for isosteres. The effects of condensation have been neglected. A concentration of the isentropic surfaces such as we see here is characteristic of a surface of discontinuity. In this case the surface separates the warm air over the lake from the air which has had no history over the water. Since the vertical extent is undoubtedly confined to the lowest three km. and the horizontal extent of the warmed air is comparatively slight, it is preferred to use the term, "Pseudo-front," which Shinze has applied to discontinuities of this nature.

The tubes or solenoids formed between the isobaric surfaces which are represented by broken lines, and the isentropic surfaces, form a measure of the acceleration of circulation transverse to the main current. It is not difficult to evaluate this force numerically, but other factors reduce its effect to such an extent that it does not appear that such calculation would be of material assistance. However, the circulation tendency, which of course, acts in such a way as to bring the isentropic surfaces into coincidence with the isobaric surfaces, is such as to cause the pseudo-fronts to rotate toward the lake at the bottom and away at the top. This means that the psuedo-fronts which are formed nearly perpendicular (at *c*) assume more and more slope as the lake is traversed. It must be observed that as these fronts move farther out into the lake (as at c^1–c^1), convection and heating in the cold air tend to destroy them—at least in the lower portion, and it seems probable that this does occur. Certainly, this effect would be greatest at the lee shore, where the front should theoretically extend farthest into the lake. These fronts will have no tendency, under ordinary conditions to become migratory since they are formed, and remain, parallel to the principal flow. This agrees with Harrison's observations. Rising air is indicated for the center of the lake, and an outflow at the top of the warmed air. This would mean a tendency for an anticyclonic eddy in the expanded portion at the top of the current and a cyclonic eddy at the lake surface, which gives us a separate, but similar picture to that obtained previously. This is nothing more than the process for the formation of a shallow thermal cyclone. Indeed, the character of distortion produced, varies between the extremes of an actual formation of a small thermal cyclone for conditions in which U_o approaches O, to merely the steepening of lapse rates with perhaps incidental squalls for the condition when U_o becomes so great that it allows insufficient time for heating as the lake is crossed.

The idealized results obtained above will be profoundly modified by three factors. First, the fact that equilibrium flow is not attained implies that only the tendency for certain of the effects considered is present. Second, the warmed air is highly unstable and active convection is taking place throughout its extent. Third, the action takes place in a sort of tunnel, totally enclosed on the sides by the psuedo fronts and on the top by the convective inversion. Under these conditions, and since the extent of the heated air is not great either horizontally or vertically, frictional drag from the air masses on either side and top of the tunnel will be very appreciable. These forces all exert a marked damping effect on all of the influences considered except surface friction.

The practical end condition which seems probable resembles in some respects the stationary whirl in a moving fluid caused by an obstruction. It is certainly not expected that a complete anticyclonic eddy will result in any cases where the gradient flow is considerable, but it is expected that a tendency to establish such a circulation should be evident even in strong flow and that the idealized circulation be closely approached for weak gradient flow.

The obvious source for data to prove such a circulation is the Great Lakes. Unfortunately, the condition is always characterized with low clouds, squalls, and precipitation, which prevent balloon soundings just when they are needed. Radiosondes would have to be more closely placed than practicable to be of much use.

Despite these objections, one case has been found that seems to illustrate some of the points considered. On March 7, 1939, a cold fairly uniform current of Pc air was flowing over the lakes from the northwest. The balloon runs from Chicago and Sault Ste. Marie, both for 0500,

TABLE 1

Altitude	Chicago	Sault Ste. Marie
Surface	330-20	[1] 320-20
1,000	330-20	330-22
2,000	330-24	340-36
3,000	320-24	340-46
4,000	310-28	330-42
5,000	300-42	320-38
6,000	300-46	310-40
7,000	300-54	310-44
8,000	300-52	

[1] Directions: W=270°, N=360°. Velocities in m. p. h.

are reproduced in table 1. The corresponding temperature soundings show adiabatic lapse rates up to 4,000 and 8,000 feet respectively. It seems fair to choose as the gradient wind for Chicago the value 24 m. p. h., and for Sault Ste. Marie, 46 m. p. h. We are interested particularly in the ratio of surface to gradient wind. For average land cases it should be about 0.5 or 0.6 for winds of these velocities, yet the ration at Chicago is 0.83 and at Sault Ste. Marie, 0.43. In the former case the ratio is much too high, indicating either too much surface wind or too little wind aloft, and the reverse at Sault Ste. Marie. While these stations are not very satisfactorily located for this purpose, nevertheless the values agree with expected results.

In a further effort to obtain supporting synoptic evidence, data from New Orleans' Shushan Airport were examined. This airport lies just east of the center on the south shore of Lake Pontchartrain. This lake is 25 miles in north-south extent by about 40 miles east-west. These dimensions are too small to expect much circulation aloft, but the surface winds should indicate such a pattern as shown in figure 2 for almost any size body of water.

TABLE 2

	West	North-west	North	North-east	East
Number of observations	8	16	33	21	21
V_{no} (modified Beaufort)	2.1	4.4	4.3	2.9	2.8
V_m (modified Beaufort)	2.2	2.4	2.1	1.9	2.1
$\frac{V_{no}}{V_m}$	.94	1.80	2.08	1.53	1.29

V_{no}=Anemometer velocity at New Orleans airport (66.1 feet above surface).
V_m=Anemometer velocity averaged for three surrounding stations. (Mobile, Tyler, Lake Charles).

The data in table 2 are taken from winter synoptic charts without regard to time but when no fronts were within a hundred miles. Diurnal effects should be practically eliminated between day and night readings. It must be remembered that the normal value for the ratio, V_{no}/V_m should be approximately 1.4 for wind directions between WNW. and E., through N., since the lower frictional drag of the water surface at New Orleans would increase the surface wind about this much above the land exposures of the surrounding stations. The west winds which are not affected by the lake, show nearly the expected value of 1.0. The NW. and N. winds, as expected, show values much greater than normal, while the NE. and E. winds show marked decreases to near or below normal. East winds should show a marked deficiency in this value, and that they do not, is attributed to the fairly uniform, low value of surface friction to the east of the airport composed of low grass marshes and water surfaces. The average wind at New Orleans from N. and NW. is found to be 4.4 modified Beaufort, or approximately 18 m. p. h. while these same directions give averages in the surrounding stations of 2.2 or about 8 m. p. h.

Table 3 is offered to show that air drainage, while perhaps a definite factor, is not the controlling force. Three New Orleans balloon runs are given for 1,100, 1,700, and 2,300, seventy-fifth meridian time April 7, 1939. They are typical of such balloon runs from north through northwest. In two of them, the ratio of V_a/V_1 is above 1.0, which is a very unusual occurrence, yet one that is probable according to figure 2. At no time does this value drop to a normal figure. The lowest ratio of 0.92 occurs at 1,100, but the wind direction of 10° to 20° which is slightly unfavorable for this effect, probably accounts for even this low a value.

TABLE 3

Altitude	1,100 ES	1,700 ES	2,300 ES	Estimated normal over sea surface for adiabatic lapse rates
Surface	360–22	360–20	350–19	
1,000	10–24	340–17	340–10	
2,000	10–20	360–16	340–10	
3,000	20–19	10–17	350–11	
V_a/V_1	0.92	1.2	1.9	0.8

V_a=anemometer wind. V_1=wind at 1,000 feet.

Some attention should be paid to the conditions of formation of the pseudo fronts mentioned before. Figure 4 shows the directions of wind which permit the formation of these fronts for each of the Great Lakes. The insert at the upper right shows how these directions were obtained. Since the lakes are not squares, it is necessary to choose the directions in such a manner that the wind blows along the edge and not across the corner of lakes. For instance, if the direction were taken as along the dotted lines marked "A" in the insert, air progressively crosses more water toward the center and a gradual zone of transition is produced instead of a discontinuity.

SUMMARY

(1) It is found that there is definite increase in surface wind velocities on the right portion of the lee shore of lakes (looking down-wind).

(2) It is probable that a marked increase in velocity at the top of the convective layer is found to the left of large warm lakes, and a decrease to the right.

(3) That the effects in (1) and (2) above vary from the formation of pure thermal cyclones, for wind velocities approaching zero, to merely a steepening of lapse rates for very high wind velocities, and a smaller lake traverse.

(4) That stationary, pseudo fronts will be formed only under certain local conditions.

THE RELATION OF WEATHER FACTORS TO WHEAT YIELDS ON LEVAN RIDGE, UTAH[1]

By NORAH E. ZINK

[Geographer, State Teachers College, Indiana, Pa., February 1940]

Much interest exists in the relation of weather to crop yields. Some of this interest is occasioned by the desire to forecast yields and thus to predict, at least in part, economic conditions at the time of harvest, or to change farm practices in order to avert loss. Some of the interest is manifested because of the desire to determine the suitability of a region to a specific method of development; the geographer uses the correlation of weather data and crop yields as a means of delimiting regions or interpreting man's activities in relation to his natural environment.

WEATHER FACTOR IMPORTANT TO WHEAT GROWTH AND YIELDS

Opinions of students of the relation of yields to weather data suggest that a large number of factors are important over wide areas. Some of these factors are the amount, distribution, reliability and effectiveness of rainfall; evaporation; maximum, minimum, and average temperatures; length of drought periods; length of growing season; and amount of sunlight and soil moisture.

Some investigators use the month or the year as a unit of time. Others are concerned with stages of plant growth; many plants have a particular period during their growth when certain weather factors or combinations of factors are thought or known to be necessary to produce large yields, and since the presence or absence of these factors at a so-called critical stage is perhaps more important than favorable weather conditions throughout the rest of the plant's life, the use of plant-growth stages as time-factors is superior to monthly or yearly divisions. There are, however, two difficulties in the use of plant-growth stages. In the first place, there are almost no records giving dates for these stages. Secondly, the dates differ from year to year, and from one place to another. Among those advocating the use of plant-growth stages in making correlations between yields and weather factors are J. Warren Smith in this country, and Girolamo Azzi in Italy.[2]

[1] The advice and assistance of Dr. John Kerr Rose in the preparation of portions of this study is gratefully acknowledged.

[2] Azzi, Girolamo, "Problems of Agricultural Ecology." MONTHLY WEATHER REVIEW, April 1922, 50: 193.

Stages in the growth of wheat which are well recognized are germination, tillering, jointing, heading, blossoming, and ripening. Two of these stages have been regarded as critical in the growth of wheat, the period of germination and formation of the first leaf, and the period of flowering.[3] The flowering period is very short and there has been some question as to whether the critical time is before, during or after flowering.[4]

Perhaps the most critical stage consists of the 3 or 4 weeks before the plant heads.[5] The date of heading is very important and is more reliable than the date of ripening.[6] From the heading date, the most critical period in the growth of the wheat, which seems to occur shortly before heading, is established. In a study of the critical periods of winter-wheat growth in Italy, Azzi found that the 20-day period just preceding heading was very important in the region studied. He said that the soil had to be kept moist at that time or the crop would be reduced.

Another supposedly critical period occurs at the time of planting when both temperature and moisture requirements are exacting.[7]

It has also been said that the yield of winter wheat will be greatly affected by the temperature of a single month or of a season.[8] In Utah the April temperature,[9] and the precipitation falling during the fallow year and in April, May and June [10] are thought to have a direct influence on yield.

PROBLEM AND PROCEDURE

The general problem was to determine which, if any, of the weather factors represented by the records were, in terms of probability, significant to the resulting yield and to what degree. The results would, of course, be strictly applicable only to the area studied but presumably of considerable validity over much wider areas of dry-farming lands in the drier part of the United States.

Levan Ridge is a dry-farming region located almost in the center of Utah near the town of Nephi. It is a small area comprising only 24 square miles, forming a rectangle in shape, 6 miles long and 4 miles wide, with nearly 15,000 acres in wheat. It is the best known dry-farm region of the State and the only area in the State which has accumulated data which might be studied in this manner.

It was possible to secure from the experiment station on Levan Ridge yields and dates covering a 25-year (1908–33) for the planting, emergence, heading and ripening of the wheat at the station. These are the average dates for 15 to 20 plots.[11] Because the averages represent a fairly large number of plots and because crop practices on the Levan Ridge follow closely those of the experiment station, these dates and yields parallel quite closely the averages for the entire area. Humidity figures were secured from the Smithsonian Institution. Other weather records were obtained from the United States Weather Bureau, Salt Lake City, Utah. Rainfall varies greatly within short distances in Utah, so it is essential that weather data should be recorded within the area furnishing the data on crop yields.

The opinions given above concerning the relation of yields and weather factors, as well as other theories, directed the choice of the climatic factors used in this investigation. In all, 120 different combinations of weather factors were studied for the 25 years for which data were available. The information concerning these factors was computed partly by calendar months and years, and partly by plant-growth stages.

In connection with planting, temperature and moisture conditions immediately preceding or following the planting date, and the period from the date of planting until the temperature dropped below 42° F. were used.[12] Much attention was given to the heading date. Data concerning rainfall, temperature, humidity, and evaporation for ten 5-day periods preceding heading were computed. These same factors were computed by 5-day intervals from heading to ripening and for the entire period from April 1 to heading. In addition to these, other factors were arranged, such as the number of days receiving 0.10 of an inch of rain; the longest rainless period; the severity of drought; maximum, minimum, and average temperatures for April; rainfall for April, May, and June; rainfall for September and October; rainfall for the year in which harvest occurred; for the actual time the wheat was in the ground; for the fallow year; and for 40 percent of the fallow year plus the rainfall of the time the plant was growing.[13]

On the Levan Ridge the date of planting at the experiment station ranged from September 15 to October 30, a range of 46 days; the date of heading ranged from June 4 to June 30, and that of ripening, from July 8 to July 29. The wheat emerged before snowfall in only 12 of the 25 years; and the period between planting and emergence covered from 9 to 43 days, requiring 17 days half of the time.[14]

Scatter diagrams showing the relation between yields and a particular weather factor were made for each of the 120 combinations in order to see if the correlations were linear. Those factors were discarded for which no correlation was discovered. About 40 diagrams indicated a fair amount of correlation between yields and the weather factor plotted; therefore simple Pearsonian coefficients of correlation were computed for them. The 15 highest of these were placed in four logical groups, and partial and multiple correlations were made for them.

Most of the simple correlations given in figure 1 are statistically significant. The higher multiple coefficients of correlation would indicate good probabilities that the weather factors represented had a rather close correlation with yield on Levan Ridge. Of the partial coefficients rainfall was most consistently significant; but over a long period of time it, too, was less significant. As with the simple coefficients, the highest coefficients obtained were for evaporation. Several of the partial coefficients are insignificant, indicating that they showed up as significant in the first order coefficients only because these were correlated with other weather factors.

Graphs, which plotted yields in a descending series, and some attendant weather factor, were made (1) in order to show the closer relationship which is disclosed when plant growth stages are employed, and (2) to show some characteristics of the weather on Levan Ridge, itself (figs. 2–9).

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[3] Alsberg, Carl L., and Griffing, E. P., Forecasting Wheat Yields from the Weather: Elements of an Unsolved Problem, Wheat Studies, vol. V, No. 1, Leland Stanford University, Junior. Palo Alto, California, November 1928, p. 19.

[4] Alsberg, Carl L., and Griffing, E. P., *op. cit.*, p. 17.

[5] Alsberg, Carl L., and Griffing, E. P., *op. cit.*, p. 16.

[6] "We find that the date of heading is a much more reliable and useful factor than the data of ripening." (Dr. John H. Parker, Professor of Crop Improvement, Kansas State College, Manhattan, Kans.—Letter, August 25, 1935).

[7] J. Warren Smith, Agricultural Meteorology (New York: Macmillan Co., 1920, p. 191.

[8] Smith, *op. cit.*, p. 199.

[9] Bracken and Stewart, A Quarter Century of Dry-Farm Experiments, Utah Agricultural College Experiment Station, Bulletin No. 222 (Logan, Utah, 1916), p. 7.

[10] Harris, Bracken, and Jensen, Sixteen Years of Dry-Farm Experiments, Utah Agricultural College Experiment Station, Bulletin No. 175 (Logan, Utah, 1916), pp. 6 and 8.

[11] Unpublished data, Utah Experiment Station, Nephi, Utah. August 1933.

[12] Alsberg, Carl L. and Griffing, E. P., *op. cit.*, p. 7. "It (the wheat plant) must cease to grow when the temperature drops to a certain point. This point varies for different kinds of plants, but for most garden crops it is close to 6° C. (42.8° F.) The British Meteorological Office adopted 42° F. as the critical point."

[13] Merrill, Lewis A. Seven Years Investigations of Dry-Farming Methods, Utah Agricultural College Experiment Station, Bulletin 112 (Logan, Utah, 1916), p. 160.

[14] Data from weather reports on file in the U. S. Weather Bureau office, Salt Lake City, Utah.

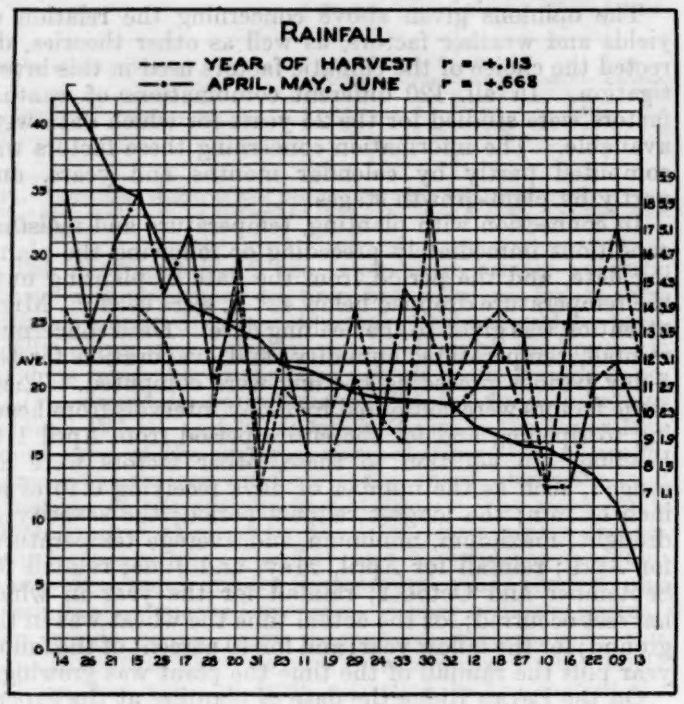


FIGURE 1

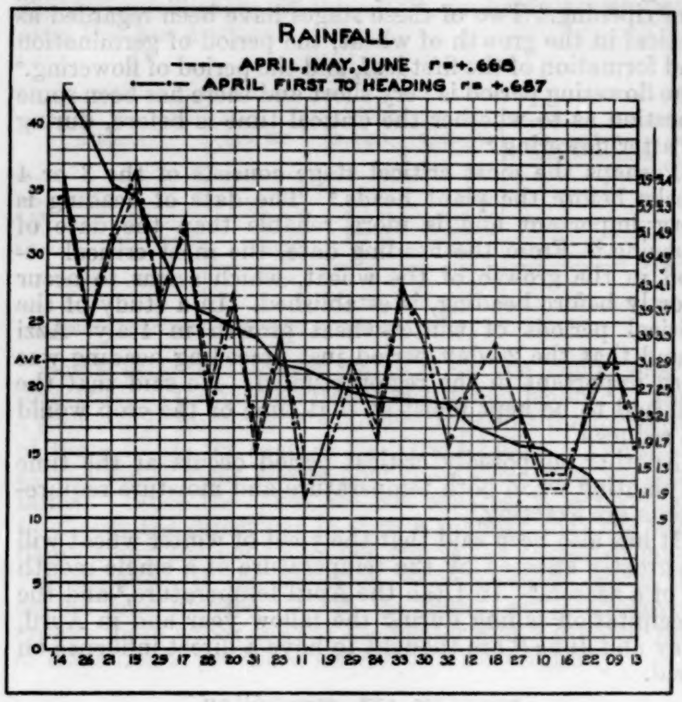


FIGURE 2

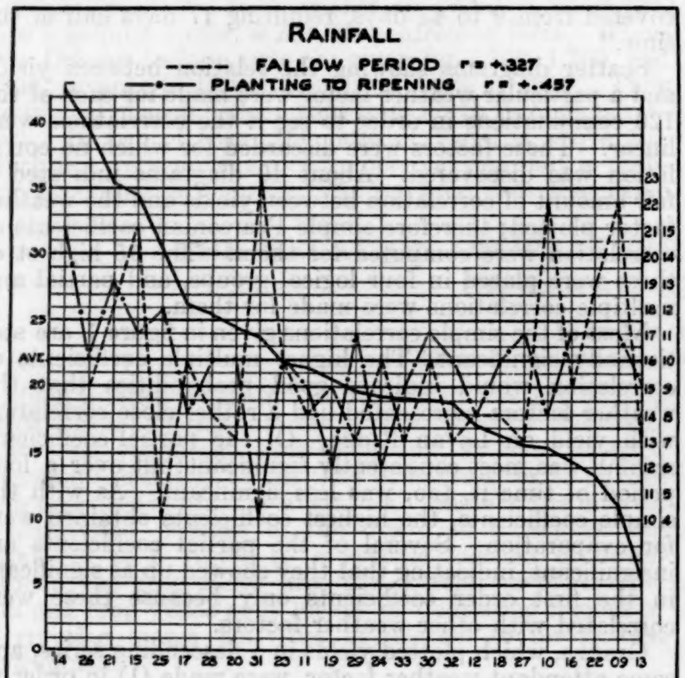


FIGURE 3

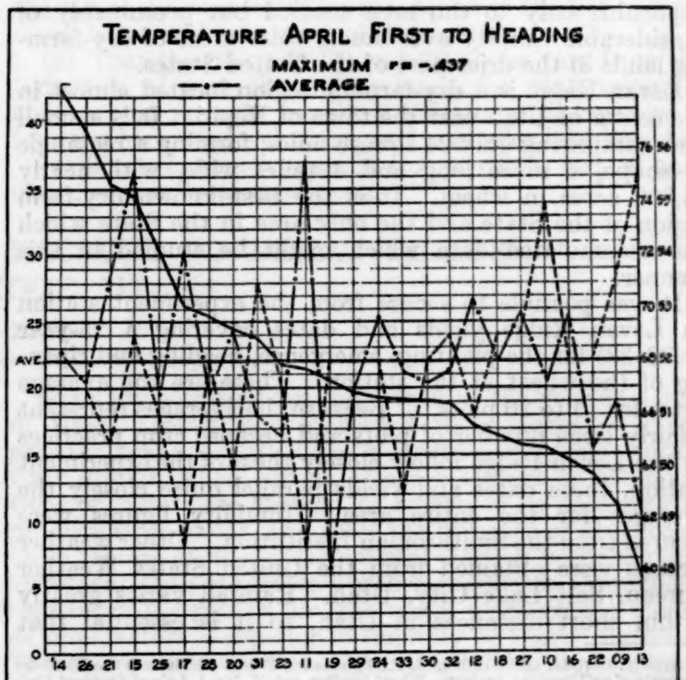


FIGURE 4

The heavy line represents crop yields in a descending series, figures for which are shown at the left. The years are given below the chart, and other data, such as rainfall, etc., are shown at the right side of the chart; figures for the factor mentioned first occurring next to the chart. The *average* line represents averages for all three factors shown.

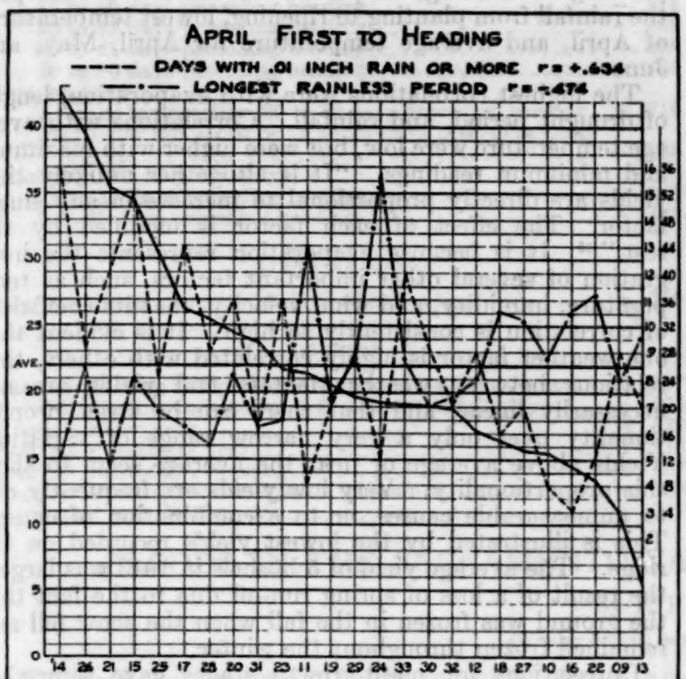


FIGURE 5

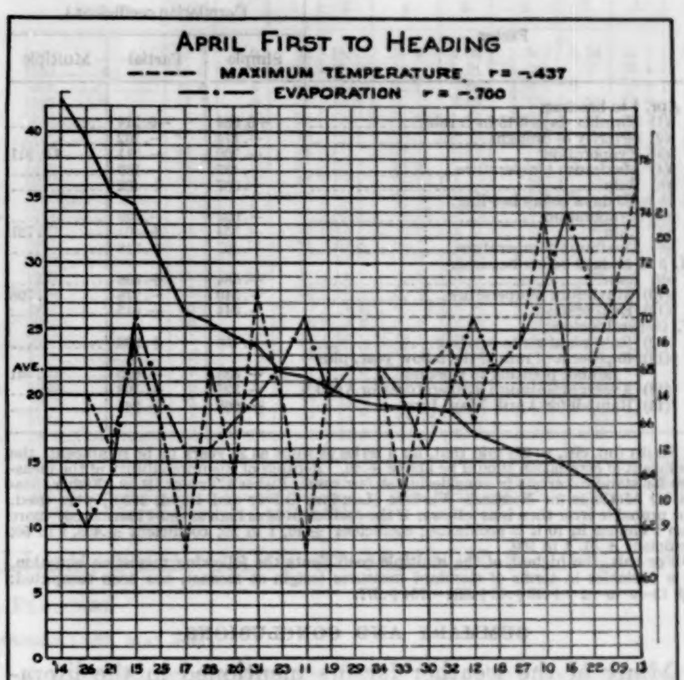


FIGURE 6

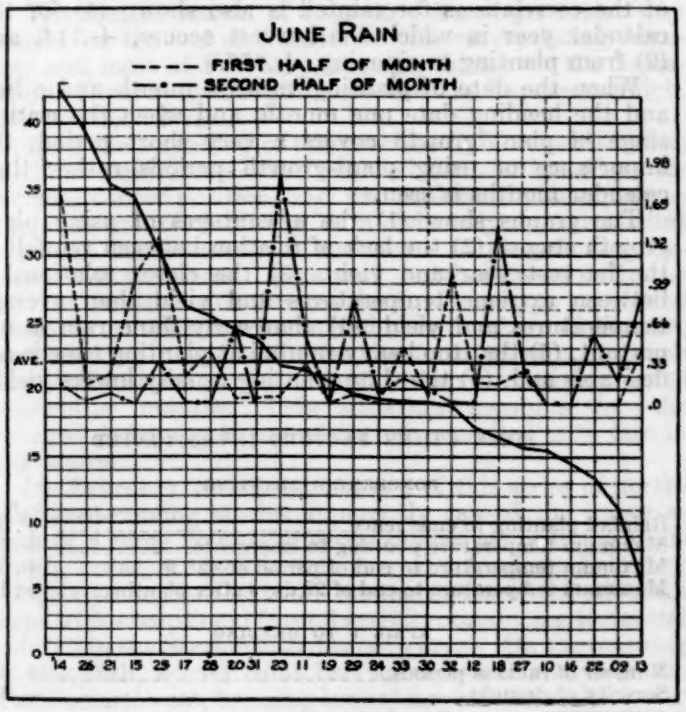


FIGURE 7

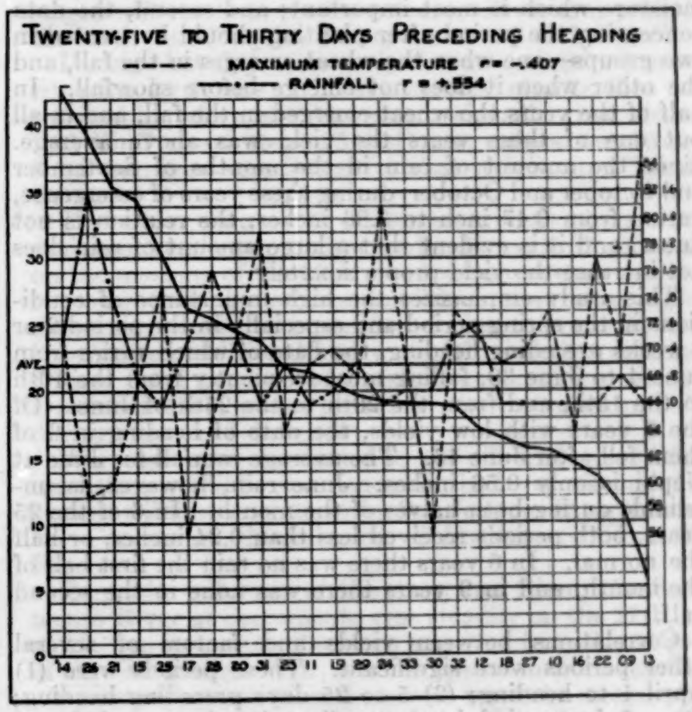


FIGURE 8

The heavy line represents crop yields in a descending series, figures for which are shown at the left. The years are given below the chart, and other data, such as rainfall, etc., are shown at the right side of the chart; figures for the factor mentioned first occurring next to the chart. The *average* line represents averages for all three factors shown.

TABLE 1.—*Correlations*

Factor	Correlation coefficient [1]		
	Simple	Partial	Multiple
I. Apr. 1 to heading:			
(1) Number days 0.10 inch rain	+0.634	−0.214	
(2) Severity of drought	−.474	−.102	
(3) Evaporation	−.700	−.511	[2] 0.811
(4) Maximum temperature	−.437	−.109	
(5) Rain	+.687	+.402	
II. 25 to 35 days before heading:			
(6) Evaporation	−.623	−.529	
(7) Rain	+.554	+.404	.721
(8) Maximum temperature	−.407	+.318	
III. 5 to 25 days before heading:			
(9) Rain	+.684	+.536	
(10) Maximum temperature	−.540	−.218	.708
(11) Evaporation	−.444	+.015	
IV. General factors:			
(12) Rain planting to heading	+.456	+.238	
(13) 40 percent of rain of the fallow year, plus rainfall planting to ripening	+.338	−.023	.531
(14) Average minimum temperatures for April	+.325	+.193	
(15) Rainfall for April, May, June	+.668	+.245	

[1] Smith (op. cit., p. 29) said that, for a series as short as 20 years to be significant, the coefficient of correlation should be above ±.40. Because of the unreliability of the measures for standard errors in considering so few cases, Fisher's Tables [R. A. Fisher, Statistical Methods for Research Workers (London: Oliver and Boyd, 1930)] were used. The probable error then is as follows: If the coefficient is as high as ±.34 there is not more than 1 chance in 10 it is accidental; coefficient ±.40, 1 in 20; coefficient ±.465, 1 in 50; coefficient ±.51, 1 in 100.

[2] For this, the highest of the multiple coefficients the following regression equation, all n variables in terms of standard measures (origin at means), has been computed: *Bij*. 12—o—o—n=+.40+.46+.084−.754+.077.

SUMMARY AND CONCLUSIONS

Many of the weather factors mentioned in the literature as influencing yield do not appear important on the Levan Ridge. Results were especially disappointing in regard to the planting period, which is commly thought to be one of the critical periods. However, the relation of the planting period to climatic factors in the fall seems to be obscured by two facts: First, that it is really soil moisture which is most important; and second, the data concerning the period after planting should be treated in two groups—one when the wheat emerges in the fall, and the other when it does not emerge before snowfall. In half of the years the wheat emerged in the fall, and in all but one of these years the yield was above average. Since the amount of rain in the months of September and October and October, during these years of emergence, varied from 0.47 inch to 3.86 inches, the relation is not linear, and it is evident that a large amount of rain does not increase the yield proportionately.

This study emphasizes the high importance of conditions in the spring period and especially in the period 2 or 3 weeks preceding heading, the date of which varies from June 4 to June 30, falling most frequently from the 10th to the 15th, and from the 20th to the 25th of June. Of the 8 years with low yields, the date of heading in 6 of them fell after June 15. The average rainfall for June at Nephi is only 0.58 inches. June rain, however, is unreliable during both halves of the month. In 6 of the 25 years, both periods received less than 0.24 inches, or half the normal. In 6 years there was no rain the first half of the month, and in 9 years there was none in the second half.

Correlations between yields and factors of several other periods were significant. These periods were (1) April 1 to heading; (2) 5 to 25 days preceding heading; (3) a 5-day period just preceding the above period and (4) a group of general factors including rainfall from planting to heading, 40 percent of the fallow rain plus the rainfall from planting to ripening, lowest temperatures of April, and average temperature for April, May, and June.

The highest correlations were with evaporation, length of drought period, and rainfall. Correlations with average temperature were low, but were higher with maximum and minimum readings. "It is altogether unlikely that yields are directly proportional to increase in any single factor. The effect of each factor is modified by the rest." [15] It is because evaporation represents the integration of several other important factors, such as temperature, humidity, and wind velocity, that its coefficient of correlation is consistently so high. It is evident that one weather factor is highly correlated with others, that relations between weather factors and yields are not necessarily linear, and that there can be strict proportionality over only a very narrow range of variation. Yields above average or near the average seem to show this proportionality. Very low yields are frequently due to unmeasurable causes, or to a combination of causes. This is illustrated by the lowest yields recorded on the ridge. The average yield of 5 bushels in 1913 was largely the result of a loss of spring run-off due to the fact that the ground was frozen in the fall when the snow fell and remained frozen throughout the winter.

Correlations for plant-growth stages gave somewhat higher coefficients than those obtained by the use of seasonal or monthly data. This is shown in a comparison of the correlations for rainfall, (1) for the three months of April, May, and June, +.668 and (2) for the period from April 1 to heading, +.687; or (3) for a period of 5 to 30 days preceding heading, +.554. A comparison of the correlations for rainfall is also shown (1) for the calendar year in which the harvest occurs, +.114, and (2) from planting to ripening, +.456.

When the date of planting varies a month and a half and the heading date one month, and when the critical stage of plant growth covers a very short period, the importance of using plant-growth periods rather than calendar months is seen.

The graphs show (1) the advantages of using plant growth stages, (2) the lack of relation between rainfall of the harvest year and yield, (3) the closer relationship between extreme temperatures and yield than average temperatures and yield, (4) that early June rain is important, (5) that too heavy rainfall at planting time is not desirable and, (6) that late planting usually lowers yields.

SOME OTHER FACTORS INVESTIGATED

CONCERNING PLANTING

	r
Rainfall planting to emergence	+.346
Maximum temperature planting to emergence	+.171
Maximum temperature to end of period of 42° F	+.395
Maximum temperature to end of 22 days after planting	+.171

APRIL 1 TO HEADING

Number of rainless periods	+.487
Severity of drought	−.367

[15] Alsberg, Carl L. and Griffing E. P., *op. cit.*, p. 21.

PERIOD PRECEDING HEADING

Evaporation:	
45 to 50 days preceding heading	−.374
40 to 45 days preceding heading	−.449
35 to 45 days preceding heading	−.508
20 to 30 days preceding heading	−.446
Temperature:	
Average temperature 20 to 30 days preceding heading	−.316
Maximum temperature 15 to 25 days preceding heading	−.436
Humidity (for 10 years only):	
25 to 30 days preceding heading	+.368
5 to 25 days preceding heading	+.117

AFTER HEADING

Average temperature for 10 days after heading	−.250

GENERAL

Rainfall planting to ripening +40 percent of fallow year	+.247
Rainfall planting to heading +40 percent of fallow year	+.274
Rainfall fallow year	+.327
Rainfall of calendar year	+.113
Rainfall planting to ripening	+.457
Number of days from emergence to heading	−.133
September and October rain	−.317

TABLE 2.—*Crop yields and weather data* [1]

Date	Yield	1	2	3	4	5	6	7	8	9
1909	11.1	9	24	16.7	70.9	3.06	1.005	0.16	69.5	0.33
1910	15.8	4	27	17.9	74	1.21	1.286	T	73.4	.51
1911	21.4	4	44	17.0	61.1	.84	1.382	0	68.8	.17
1912	17.1	9	24	16.8	66	2.69	1.375	.55	70.8	.72
1913	5.4	7	30	18.3	74.65	1.63	1.508	.02	84.3	.46
1914	42.7	16	12	11.1	66.7	5.70	.679	.34	71	2.26
1915	34.2	15	24	17.2	68.77	5.75	.794	.18	66.8	1.04
1916	14.6	3	34	20.5	68.05	1.24	1.049	0	63.6	.00
1917	26.1	13	17	12.2	60.55	5.12	.467	.45	56	1.73
1918	16.4	6	34	15.1	69.05	1.91	1.226	0	68.8	.06
1919	20.6	7	21	13.8	68.05	1.70	.977	.14	70.4	.91
1920	24.4	11	25	12.7	64.09	3.81	.955	.53	70.6	.55
1921	35.4	12	11	10.8	64.7	4.80	.712	.84	60.2	1.72
1922	13.6	5	37	18.0	68.3	2.28	1.319	0	77	.00
1923	21.8	11	18	14.7	66.8	3.31	.701	.28	64	.94
1924	19.3	5	55	14.5	68.4	1.91	1.435	0	80.5	1.84
1925	30.3	8	19	14.1	65.92	3.60	1.174	0	74.6	1.39
1926	39.4	9	26	9.4	66.8	3.43	.535	1.58	59.4	1.65
1927	15.7	7	33	16.1	68.8	2.14	.977	.01	70.4	.26
1928	25.6	9	14	12.1	67.6	2.29	.732	1.03	65.2	1.52
1929	19.7	9	27	15.0	67.8	2.92	.941	.29	68.4	1.51
1930	19.0	9	20	11.7	68.2	3.23	.321	.11	56.2	.30
1931	23.7	6	17	13.8	70.9	1.70	1.232	0	79.2	.50
1932	18.9	7	21	14.2	68.78	1.61	1.194	.50	73	1.58
1933	19.2	12	27	13.5	62.50	3.98	1.279	.08	68.6	.11

[1] Figures in column 1 show number of days with .10 inch of rainfall from April 1st to Heading. 2 Severity of drought (number of days in longest rainless period) etc. See arabic numbers in Figure 1, for other titles.

FLOODS IN THE SACRAMENTO VALLEY, FEBRUARY 27–MARCH 6, 1940

By E. H. FLETCHER

[Weather Bureau, Sacramento, Calif., May 1940]

The flood that occurred in the Sacramento Valley late in February may well be classified as one of first magnitude, exceeding that of December 1937, and in some respects surpassing any flood since systematic records have been kept by the Weather Bureau. From Kennett, Calif., to the mouth of the Feather River, new all-time high water marks were established generally.

The rainfall season of 1939–40 did not get under way until near the end of December. However, during January and most of February frequent rains over the Sacramento River system kept the streams and bypasses at high, but not flood levels.

Near the beginning of the year the California-Hawaiian high-pressure system had receded far southward of its normal winter position, and was replaced by storm areas of much greater intensity than ordinarily appear in that region. Consequently, a succession of slow-moving cyclonic disturbances, advanced northeastward off the Pacific coast, with intermittent warm-type occluded cyclonic systems moving inland over northern California, and causing precipitation in the form of rain at much higher elevations in the mountains than is usual during the midwinter months. This situation accounts for the marked deficiency in snowfall that prevailed until late in the season.

On February 24–25, the last one of this series of northeastward-moving storms apparently caused the importation of a large volume of semi-tropical air near the California coast, whence it was carried inland on February 27–28 by another and more intense storm of the Aleutian type with exceptional frontal activity, producing torrential rainfall in the Sacramento drainage area. On the morning of the 29th, a cold front had advanced inland over the Pacific northwest, bringing lower temperature and snow to the mountains, with clearing weather following. Thus ended a cycle of storms that was directly responsible for the disastrous flood of February.

The excessive rainfall was mostly confined to the 5-day period, February 25–29, with the most intensive fall occurring on the 27th–28th. However, the antecedent rainfall extending over a period of about 2 months, was a highly important contributing factor to the flood-producing run-off.

It was apparent as early as Monday morning, February 26, that a period of high water was inevitable, and the river bulletin that morning contained the following general forecast: "A general rise is developing in all streams, and with continued heavy rains in prospect, high stages will result in the Sacramento River and probably the lower San Joaquin, during the next 2 or 3 days."

During that day a close check was maintained on the situation by means of hourly weather reports that were received by teletype. At 5 p. m., when the river stage at Red Bluff (flood stage 23 feet) was only about 13 feet, flood warnings were issued for that vicinity and Tehama County.

The upper courses of all streams in the Sacramento drainage area began to rise rapidly during that night, and on the morning of the 27th, flood warnings were repeated, stressing that the serious conditions that were rapidly developing would be intensified during the next 24 hours by expected additional heavy rainfall, and that extremely critical flood conditions, equaling or exceeding those of December 1937, would prevail in the Sacramento Valley during the next 3 days.

Warnings were also issued to the effect that mild flood conditions would be experienced in the lower reaches of the eastern tributaries of the lower San Joaquin River, namely, the Consumnes, Mokelumne, Calaveras and Stanislaus Rivers.

From the influence of the American River, the Sacramento River at Sacramento rose steadily on the 27th, and at 10:30 p. m., when the stage was 28.5 feet, the 48 gates of the Sacramento Weir, 3 miles upstream from the City, were opened, permitting the excess water to escape westward into the wide expanse of the Yolo Bypass, which conducts the water southward to the vicinity of Rio Vista, where it reenters the broad river channel.

After the weir gates were opened the river at Sacramento fell during the next 5 hours to 26.5 feet and remained practically stationary for several days. The city of Sacramento was at no time endangered.

As soon as it was known that the Sacramento Weir gates would be opened, thus diverting a large volume of the Sacramento River flow into the bypass, warnings were distributed to all those having interests in and adjacent to the lower Yolo Bypass, informing them that the water level in that basin within the next 48 hours would rise rapidly, and the so-called tidal reclamation tracts would be flooded.

At the beginning of the flood period there was very little snow below the 5,000-foot elevation in the Sierra Nevada mountains. Above 6,000 feet, rain and snow fell intermittently at first, but turned to snow later at the higher elevations. While there was some water released by the complete melting of from 12 to 15 inches of snow in the vicinity of the 5,500-foot level, it was not so important as compared with the effect of the unrestricted run-off from rainfall below 6,000 feet, due to absence of the normal snow pack.

Because of the northward movement of the main storm center off the Oregon coast, the region of high-intensity rainfall was confined to the upper half of the Sacramento River drainage basin, including the headwater areas of the Feather River, Putah, Cache, and Stony Creeks.

Following 4 days of torrential rains, centered in the Sacramento River canyon, the river at Kennett crested on the morning of February 28, at the momentous stage of 36.3 feet, which is 3.1 feet higher than the previous high record in 1907, and 7.3 feet higher than in December 1937. By 5 p. m. of the 28th, the flood crest had reached Red Bluff with a stage of 32.2 feet, which is 9.2 feet above the flood stage and 0.2 foot above the previous high-water mark which was established in 1937. Table 1 shows the crest stages reached at various points along the Sacramento and tributaries as well as comparative data.

TABLE 1.—*Crest stages and comparative data, high water, February–March 1940*

Station and river	Crest stage	Time and date	Departure from flood stage	High stages previous floods: Prior to December 1937	December 1937
Sacramento River					
Kennett	36.3	9 a. m. Feb. 28	+11.3	33.2, March 1907	29.0
Red Bluff	32.22	5 p. m. Feb. 28	+9.2	30.5, February 1909	32.0
Hamilton City	22.64	4 p. m. Feb. 28	+2.6	20.6, March 1928	22.8
Ord Ferry	121.6	7 p. m. Feb. 28			121.0
Colusa	29.5	6:30 a. m. Mar. 1	+1.5	29.3, March 1907	26.8
Knights Landing	34.05	8 a. m. Mar. 1	+4.0	32.2, March 1907	32.6
Sacramento	28.5	11:10 p. m. Feb. 27	−.5	29.6, January 1909	27.7
Feather River					
Oroville	25.1	12:01 a. m. Feb. 28	+.1	28.2, March 1907	26.3
Nicolaus	26.3	6 p. m. Feb. 29	+1.3	23.2, March 1928	24.6
Yuba River					
Colgate	14.8	9:35 a. m. Feb. 27		23.4, March 1928	22.0
Secondary crest	14.8	12:30 a. m. Feb. 28			
Marysville	25.0	11 p. m. Feb. 28	−3.0	24.0, March 1928	25.7
American River					
Folsom	19.1	1 a. m. Feb. 28		26.8, March 1907	23.9
H Street Bridge	39.2	4 a. m. Feb. 28	−.8		
Stony Creek					
St. John	13.9	2:30 p. m. Feb. 28	+1.9	13.2, March 1907	12.0
Mokelumne River					
Bensons Ferry	13.3	7 a. m. Feb. 29	+1.3	14.3, February 1936	14.4
San Joaquin River					
Lathrop	14.4	11 a. m. Mar. 2	−2.6	22.5, February 1911	5.2
Yolo Bypass					
Lisbon	22.8	9 a. m. Mar. 1			
Liberty Is. Farms	17.97	10 a. m. Mar. 1			

Intensive rainfall was centered in the Sacramento River canyon area above the Shasta Dam construction site. At Kennett 12.51 inches of rain fell in 2 days. Other high 48-hour amounts are: Hobergs, Lake County, 16.55 inches; and Stirling City, on the West Branch of the Feather River, 15.20 inches. The greatest 5-day rainfall, 20.15 inches, also occurred at Stirling City. Table 2 shows the daily rainfall during the storm period for most of the mountain stations in this river district.

TABLE 2.—*Rainfall from Feb. 22 to Mar. 2, 1940, inclusive* (inches)

Stations	Elevation, feet	February 22	23	24	25	26	27	28	29	March 1	2	Total
Sacramento River												
Mineral	4,950	.20	.10	.20	.90	1.90	.30	2.40	.30	0	0	6.30
Mount Shasta	3,555	.09	T	.27	.42	.72	2.20	3.50	.38	T	.25	7.83
McCloud	3,270	.02	.07	1.37	1.06	2.86	4.18	1.45	0	.33	0	11.34
Hobergs	2,980	0	0	.05	.50	1.15	8.42	8.13	1.39	.06	0	19.70
Kilarc P. H.	2,642	.16	.24	.33	.48	.49	1.73	1.95	.59	0	.50	6.47
Dunsmuir	2,300	.17	T	.61	2.32	1.37	3.61	4.15	1.10	0	.34	13.67
Montgomery Creek	2,145	.17	.41	.36	.81	.62	3.62	4.20	.58	.38	0	11.15
Volta P. H.	2,100	.25	.04	.11	.24	.65	1.22	1.42	.39	0	.32	4.64
Clear Lake	1,350	0	0	.04	.16	1.37	2.42	2.78	.34	0	0	7.11
Vollmers	1,332	.07	.10	1.31	.51	4.70	3.92	3.56	0	.38	0	14.55
Beegum	1,291	0	0	0	.06	.83	1.60	2.30	.08	0	.05	4.92
Stonyford	1,205	0	0	0	.28	.32	2.44	2.97	.12	0	0	6.13
Middletown	1,105	0	0	0	.42	.53	6.48	4.25	1.30	0	.05	13.03
Squaw Creek	900	.09	.05	.40	1.50	.93	5.08	5.32	1.75	0	.40	15.52
Stony Gorge Reservoir	800	.02	.07	.10	.25	.81	1.70	2.21	.11	0	.01	5.28
Paskenta	740	.04	0	0	.27	.14	1.67	3.02	0	0	0	5.14
Redding	718	T	.03	.58	.36	3.68	3.28	1.02	T	.26	0	9.21
Kennett	655	.10	.01	.05	1.12	.70	5.41	7.10	.23	0	.23	14.95
Sacramento	25	.01	.06	T	.88	1.46	2.19	1.01	.02	0	0	5.63
Feather River												
Bucks Storage Reservoir	5,070	T	.39	.12	.90	3.05	7.42	4.88	1.09	0	T	17.85
Canyon Dam	4,570	.02	.06	.20	.91	1.98	4.27	3.12	.79	0	.04	11.39
Stirling City	3,525	T	T	.08	1.15	1.71	8.49	6.71	2.01	.02	.32	20.49
Brush Creek	3,500	0	0	.14	1.02	1.24	7.24	5.15	1.68	.03	.19	16.69
Quincy	3,409	0	T	T	.40	1.87	4.48	3.31	1.10	0	.03	11.19
West Branch	3,216	.03	.01	.07	1.62	3.45	6.73	4.64	1.49	0	0	18.04
Feather Falls	2,973	0	0	.95	1.24	5.50	3.78	1.22	0	.09	.30	13.08
De Sabla	2,700	T	T	.02	1.50	3.50	7.00	3.58	1.62	0	.25	17.47
Challenge	2,700	0	.20	0	1.67	3.57	5.33	2.50	1.30	.15	0	14.72
Bucks Creek	1,750	.02	0	.14	1.00	2.20	5.70	4.45	1.92	0	.30	15.73
Las Plumas	569	0	0	.01	1.07	3.13	7.66	2.11	1.13	0	.10	15.21
Oreville	273	0	0	0	.45	.55	2.45	1.85	.33	0	T	5.63
Yuba-Bear River												
Bowman Dam	5,347	T	1.15	.27	1.75	2.09	4.28	2.42	1.91	T	.36	14.23
Lake Spaulding	5,070	.06	1.42	.24	1.42	1.92	5.60	2.37	2.40	T	.21	15.64
Scales	4,300	0	.38	0	1.60	2.65	6.75	3.60	2.42	0	0	17.40
Deer Creek	3,700	.01	1.12	.06	1.48	2.16	5.41	2.93	2.71	0	.20	16.08
North Bloomfield	3,100	0	.32	.42	.75	.85	5.27	3.65	2.45	.27	.31	14.29
Downieville	2,890	0	.29	.55	1.09	.64	6.71	4.59	2.95	.37	.16	17.35
Camptonville	2,850	.12	.39	.12	1.83	2.64	2.73	2.33	.75	.10	.14	11.15
Nevada City	2,570	0	.25	.35	.91	1.05	4.44	3.15	2.36	0	.12	12.63
Chute Camp	1,358	0	.25	.08	1.85	1.96	3.05	1.46	1.40	.21	0	10.26
Colgate	582	0	.08	.67	1.59	2.66	1.92	1.06	0	0	.14	8.12
American River												
Twin Lakes	7,920	.12	1.20	0	T	.50	3.64	1.89	.70	0	T	8.05
Soda Springs	6,752	0	.76	.48	.38	.62	3.00	2.75	1.13	.07	.13	9.32
Blue Canyon	4,750	.16	.84	.97	.73	1.25	3.72	2.83	1.90	.21	.31	12.92
Riverton	3,230	0	1.10	.07	.33	.51	2.72	2.21	1.73	T	0	8.67
Gold Run	3,227	0	.43	.73	.11	1.53	3.58	2.96	2.85	.34	.27	12.80
Iowa Hill	2,970	0	.75	0	.96	.67	3.53	2.30	1.64	.15	.20	10.20
Colfax	2,421	0	.62	.59	.32	1.05	2.46	2.95	1.96	0	0	9.95
Georgetown	2,300	.41	1.55	0	1.33	1.85	2.45	2.03	1.02	.40	0	11.04
Foresthill	2,200	0	.88	.75	.95	.90	3.40	2.25	2.00	.20	.13	11.46
Placerville	1,925	.23	1.13	0	.47	1.21	3.73	1.05	1.08	0	.11	9.01
El Dorado P. H.	1,887	.16	1.85	.03	.55	.93	4.43	1.46	1.25	0	0	10.66
Folsom	252	0	.26	.03	.52	.75	2.01	1.47	.58	0	0	5.62
Cosumnes River												
Fiddletown	2,100	.33	.84	0	.37	1.36	1.54	1.05	.58	.05	.05	6.17
Big Canyon Mine	850	0	0	0	0	2.09	1.43	.95	1.29		.12	5.88
Calaveras River												
San Andreas	996	0	.50	.46	.16	.35	2.11	1.50	.89	.05	.01	6.03
Tuolumne River												
Hetch Hetchy	3,530	T	1.28	.92	.03	.72	1.34	.63	1.14	.06	0	6.12
Sonora	1,825	.38	1.32	0	.38	.29	2.98	.52	.54	0	.02	6.44

In contrast to the meteorological conditions that immediately preceded the 1937 flood, when an extensive overrunning semitropical Pacific air mass aloft caused almost

unprecedented excessive rains to reach the Sierra summit with dashing run-off in headwater areas, the recent storm by comparison was not so intense at high elevations, although the period of effective rainfall this year embraced about 7 days, as compared with about 3 days in 1937.

While the rainfall in the February storm was excessive, it was not of the heavy cloudburst type generally in the higher mountains, as was characteristic in 1937. Consequently, the streams, although substantially higher this year, did not rise with such great rapidity, but the high flow in the river was sustained for several days longer this year, a condition that was especially damaging to levees, particularly on March 1, when accompanied by strong north winds that induced destructive wave action.

The development of this flood in record proportions resulted largely from the fact that the requisite conditions necessary for high water were being built up over a period of 2 months. From continued rains the soil was thoroughly saturated and in a condition for a high percentage of run-off over a watershed with a comparatively high snow line. Also the streams and bypasses were already carrying large volumes of water. Preceding the 1937 flood, some of these factors were not so highly developed.

Some of the remarkable features of the recent flood were: (1) Notwithstanding the unparalleled high water in the upper Sacramento River, Stony Creek with even greater abnormality, caused the Sacramento River from Hamilton City to Butte City to crest in advance of the upstream peak flow. (2) Immediately following the break in the levee on the Sutter and Tisdale Bypasses, the water level in the river and bypasses fell rapidly downstream, reaching the Delta region within a few hours, whereas the usual time interval is about 2 days. (3) Another feature was the long flood wave that was in progress from Kennett to the mouth of the Feather River on February 28, forming an unbroken wall of flood water for about 250 miles.

It is believed that adequate and timely warnings were issued by the Weather Bureau when early in the storm's development warnings were issued to the effect that conditions would equal or exceed the 1937 flood. These warnings were consequently of inestimable value to farmers, stockmen, reclamation district officials, engineers, Red Cross officials, and others affected by the water situation; as all interests knew what to expect, because memories of the 1937 flood were still in mind.

The extraordinary vigilance that was maintained by supervising engineers and reclamation officials throughout the valley in safeguarding levees that were severely strained, and in repairing hundreds of minor breaks, was instrumental, no doubt, in preventing wholesale disaster in many areas. For example, the Sutter Basin with a 60-mile levee system, was saved only by desperate efforts.

The magnitude of this flood in the upper Sacramento Valley can be realized by considering that it is the greatest for a period of about 40 years, or since authentic records have been kept. However, farther down the river, where the flood-control system with its bypasses and levee-construction work has been constantly changing conditions, the present river-gage heights are not comparable with those of earlier years and consequently are not a true index to the volume of water that is being discharged by the system. Yet it is true that the gage readings are representative of the danger present and indicate the responsibility of the Weather Bureau in issuing adequate warnings.

Before there was any flood-control system in operation in the Sacramento Valley, the overflow waters drained into natural basins of unreclaimed land on each side of the river. Under present conditions where the water is confined to leveed channels, gage heights are not only proportionately higher for the same volume of water, but failures in levees are more disastrous because more reclaimed lands are affected. This, in a general way, explains why the Weather Bureau, being primarily concerned with floods, uses the river gage height as a measure of flood danger instead of the flow in second-feet. In this connection it may also be explained that the gage height representing the "flood stage" that is assigned to a station on a leveed stream represents the "danger stage" rather than overflow stage.

Overflow due to the high water was extensive. Some of the major inundations and the acreage affected are as follows:

East of Hamilton City 60,000 acres were under water. This was considerably more than in 1937 although the crest at Hamilton City was 0.2 foot lower than in 1937.

During the early morning of the 29th, numerous levee failures in the Butte City-Princeton area caused increasing overflow on both sides of the river. On the east side, the combined overflow waters from the river and from Butte and other creeks, en route to Sutter Bypass, covered an area of about 145,000 acres in the Butte Basin, which contained mostly grain land. On the west side of the river, water escaped from a dozen breaks between Ord Ferry and Princeton and covered about 120,000 acres of reclaimed land in the Colusa trough area.

At the peak of the flood wave, on the early morning of March 1, failure of the levee on Sutter Bypass, east of Meridian and on the north side of Tisdale Bypass, caused inundation of 37,000 acres of highly valuable farm land.

In the Yolo Bypass and the adjacent Delta region, the total acreage of the five principal island tracts flooded was approximately 30,000.

In addition to the flooding of farm lands, the outskirts of many towns in the central valley were flooded and were more or less isolated for a period of time because highways and railroads became impassable and wire and power lines were decommissioned.

All persons in the inundated areas were generally warned in advance to evacuate the danger zones. There were some cases in farm districts where families were marooned in houses by the sudden breaking of levees, but these persons were rescued in boats by the Red Cross and other workers. According to records of the American Red Cross no persons were injured but two lives were lost.

A very special effort was made to secure reliable statistics of losses sustained by reason of the flood. The tabulation below is the result of questionnaires returned from authentic sources of information. Judgment was exercised to exclude any overlapping estimates in reports from different sources. The items were obtained mostly from County and State officials. Comparisons were also made with the State Engineers Office which collected similar data. The figures given by the Weather Bureau relate to the Sacramento and lower San Joaquin Valleys, and include losses occasioned by stream flow only.

For the Sacramento and Lower San Joaquin Drainage Areas:

Estimated total property damage of all kinds caused by stream flow [1]	\$6, 731, 054
Estimated value of property saved by warnings	\$2, 060, 000
Total acreage of agricultural lands flooded (approximately)	508, 798

[1] Not included are general storm damages, such as from wind, and earth slides and erosion in the mountains. The State of California, Public Works Department, estimates a loss of \$12,041,600, covering all losses from the storm for the entire state.

Acknowledgment is made of the valuable assistance given by all of the observers who stuck to their posts and

made rainfall and river-gage readings frequently during day and night; of the aid given by United States engineers who, particularly in one case, assigned two of their employees at Marysville to help our river observer during the emergency, the engineers, in day and night shifts taking hourly readings and answering hundreds of telephone calls as to the behavior of the river; also of the valuable cooperation of the telephone and telegraph companies, the radio and the press, in distributing warnings.

In this connection it should be stated that the Red Cross and other agencies promptly provided all necessary relief and rescue facilities throughout the Valley.

NOTES AND REVIEWS

O. HOELPER. *Atmosphärische Trübungs-und Wasserdampfbestimmungen nach Filtermessungen der Sonnenstrahlung.* **Reichsamt für Wetterdienst, Wiss. Abh. *5*, n. 10, 49 pp., Berlin, 1939**

Filter measurements of solar radiation, and their reduction by Ångström's method to obtain dust turbidity and precipitable water in the atmosphere, are here published for Potsdam, Schomberg, Davos, and Zugspitze. Data for Aachen have already appeared (Deutsches Met. Jahrb. Aachen für 1933, 55–62, 1935).

The practical difficulties in the way of getting sufficiently accurate solar radiation measurements seem to have been to a large degree responsible for the limited use of this theoretically very simple method for getting the total moisture content of the atmosphere above any station. These difficulties are here reviewed. It is pointed out that concurrent readings from several stations all within the same air mass have helped to remove some of the errors; conversely, agreement in the results of independent and well-separated simultaneous observations has emphasized the uniformity in some of the characteristics of an extended air mass.

Theoretical difficulties of the Ångström method, such as the assumption of a mean effective size of scattering particle, and the anomalous behavior of scatter in the UV region, are claimed to be of little consequence in view of the rough nature of the required characterizations of the atmosphere.

Hoelper sets up a transformation table to put the results of observations at Blue Hill and Washington (published in the MONTHLY WEATHER REVIEW, 1933–37) in terms of the European reductions. Much of the disparity in the Blue Hill results is supposed by Hoelper, as by Kimball, to be probably traceable to improper filter transmission factors. It may be mentioned here that in September 1938 it was discovered at Blue Hill that both the OG–I and the RG–2 Jena glass filters, continually exposed there in clear or partly cloudy weather during the previous 5 years, had steadily deteriorated by crystallization at and just below the glass surfaces. Subsequent development of an empirical method for estimating the curve of transmission decrease of these filters with advancing time made possible the reevaluation of Blue Hill turbidity measurements now under way.

Hoelper discusses a new method for correcting the reductions to turbidity and water-vapor content on nonnormal days. It was found that observations indicating extremely high or low turbidity did not yield true values of precipitable water by the usual reductions. By the use of simultaneous airplane observations of atmospheric moisture content, a correction curve may be developed for any station, based on the differences between the precipitable water found by the two methods, plotted against the differences in the corresponding turbidity coefficient obtained from two spectral regions. This curve permits adjustment of the quantity of precipitable water obtained through radiation measurements and use of the corrected quantity to obtain a truer value of the turbidity. A few successive approximations suffice for even the most extreme conditions. It is felt by Hoelper that this method provides, where necessary, at least a partial correction for the Ångström approximation in assuming a mean effective size of scattering particle.

Another subject discussed by the author is the frequently observed inconsistency between the surface vapor pressure and the precipitable water as obtained by the filter method. The mean relation between the two does not conform to theory, for a nonlinearity appears when they are plotted in a scatter diagram. This is similar to the nonlinearity found in recent spectrographic measures of water-vapor absorption when plotted against the corresponding surface vapor pressure (Herzing, *Gerl. Beitr. 49*, 71, 1937). It seems to be accounted for by considering Fowle's absorption F, due to water vapor, not as a mean function of $W \cdot m$ (where m is the optical air mass) but as a family of curves, each of constant m. It then appears that for large m, F falls below the mean F for all W; and for small m, F lies above the mean F. Thus an observed F in winter (with relatively large m) should yield a much higher value of $W \cdot m$ than the same F in summer. It is of course understood that the preceding correction only partially meets the difficulties inherent in approximating the total precipitable water from the surface vapor pressure.

Perhaps the outstanding contribution of this paper is in calling attention to the importance of essentially simultaneous solar observations. Confirmation of the results of one set of observations by the results of an entirely independent set is one of the fundamental "controls" in scientific research. For estimating the effects of the especially numerous known and unknown sources of error afflicting solar radiation measurements, particular emphasis on concurrent observations offers one of the most important possibilities.—*Edmund Schulman.*

W. W. SPANGENBERG. *Strahlungs—Klimatologische Betrachtungen.* **Aus d. Archiv d. deutschen Seewarte, *58*, n. 8, 32 pp., 1938.**

The author compares the mean monthly values of transmission, turbidity, and maximum intensity of both the total and the red-infrared radiation at eight stations of varying elevation in central Europe. The differences are discussed in terms of variations of the climatic elements in place and time.

Of especial interest is the discussion of intensity fluctuations of a few minutes duration. In absolute value as well as in percent, these fluctuations are shown to vary inversely with the solar elevation, for the total as well as for the less fluctuating red radiation. Variations up to 30 percent for large air masses are found. Wind, in combination with stratified or otherwise heterogeneous distribution of dust and other scattering and absorbing particles, is held to be the causative agent. The effect of the lowest layers of the atmosphere in introducing long-period (month-to-month) variations in radiation is emphasized; at relatively high solar elevations these variatinos apparently smooth out.—*Edmund Schulman.*

SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, MARCH 1940

By DAVID HABER

Measurements of solar radiant energy received at the surface of the earth are made at nine stations maintained by the Weather Bureau, and at ten cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver-disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, then departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities during March at Washington and Madison averaged close to normal. The data for Blue Hill will be published in the April Review; the Lincoln normal incidence data are of questionable validity because of instrumental trouble.

Total solar and sky radiation averaged considerably below normal at Lincoln, and somewhat below normal at Chicago, Fresno, La Jolla, and Riverside. Sizable excess departures were recorded at New York, New Orleans, Blue Hill, and Friday Harbor.

No polarization measurements were obtained at Madison, Wis., because of almost continual snow cover.

TABLE 1.—*Solar radiation intensities during March, 1940*

[Gram-calories per minute per square centimeter of normal surface]

Date	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	* 1.0	2.0	3.0	4.0	5.0	e
WASHINGTON, D. C.											
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
March 8	3.45	0.80	0.87	0.90	1.01						3.63
March 11	1.88				.88						1.32
March 12	.81				1.39						1.19
March 25	1.07				1.19	1.55					.74
March 26	1.45			.92	1.04						1.45
Means		(0.80)	(0.87)	(0.91)	1.10	(1.55)					
Departures		+.07	+.06	−.04	−.05	+.12					
MADISON, WIS.											
March 7	1.88		.81	.98		1.43					2.87
March 11	1.32		.96	1.13	1.24	1.44					2.49
March 16	2.16	.92	1.04	1.15		1.44					3.30
March 19	2.87	1.04	1.14	1.26	1.42	1.55					4.37
March 20	1.96				1.42	1.61					2.87
March 22	.81	1.10	1.18	1.33	1.45	1.60					1.45
March 23	.91	.96	1.07	1.19	1.39	1.55					1.37
March 25	1.07	.90	1.02	1.16	1.37	1.58	1.21				1.32
March 30	4.75			.55	1.07						6.76
Means		.98	1.03	1.09	1.38	152	(1.21)				
Departures		+.09	+.02	−.06	+.07	−.04	−.08				

* Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Albuquerque	La Jolla	New Orleans	Riverside	Blue Hill	Newport	Friday Harbor	Cambridge
	Gram-calories per square centimeter													
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Feb. 26	158	143	179	78	192	280	391	435	366	412	348	299	155	310
Mar. 4	350	354	197	216	272	445	516	444	372	456	257	291	204	247
Mar. 11	306	281	337	301	344	477	609	492	383	483	432	430	246	402
Mar. 18	426	480	316	264	435	474	603	306	353	327	407	420	400	389
Mar. 25	366	342	376	268	315	296	580	372	307	255	368	385	303	369
	Departures from weekly normals													
Feb. 26	−123	−127	−140	−120	−51	−102		+29	+105	+26	+37	+17	−8	
Mar. 4	+38	+51	−137	+1	+16	+45		+50	+46	+34	−41	−17	0	
Mar. 11	−12	−37	−32	+68	+80	+56		+92	+28	+58	+125	+78	+45	
Mar. 18	+82	+154	−76	+11	+123	+25		−102	−14	−42	+12	+20	+126	
Mar. 25	+20	−14	−5	+15	+34	−175		−98	−12	−125	−11	−8	−8	
	Accumulated departures on Mar. 31													
	+1,183	+616	−3,409	+273	+2,688	−1,890		−1,267	+1,512	−2,471	+1,650	+833	+1,764	

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data from measurements at the U. S. Naval Observatory from plates obtained at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day below longitude, latitude, area of spot or groups, and spot count, are given, respectively, the assumed longitude of the center of the disk, assumed latitude of the center of the disk, total area of spots and groups, and total spot count]

Date	Eastern standard time		Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Spot or group	Spot count	Plate quality	Observatory
1940	*h*	*m*		°	°	°	°				
Mar. 1	13	20	6763	−60	39	−16	60	48	5	G	U. S. Naval
			6761	−37	62	−15	38	24	2		
			6758	−8	91	−5	8	582	33		
			6757	+7	106	−10	7	12	1		
			6756	+11	110	+10	21	24	3		
			6756	+17	116	+18	31	48	1		
			6756	+26	125	+12	33	48	2		
			6756	+31	130	+10	35	388	1		
			6762	+48	147	−9	48	339	15		
			6755	+64	163	−14	64	48	1		
					(99)	(−7)		1,561	64		
Mar. 2	12	37	6763	−47	40	−17	47	145	4	P	Mt. Wilson
			6764	−28	59	+3	30	12	1		
			6758	+6	93	−5	6	679	29		
			6756	+44	131	+10	47	388	3		
			6762	+62	149	−8	62	291	11		
			6755	+78	165	−14	79	24	2		
					(87)	(−7)		1,539	50		
Mar. 3	11	52	6763	−33	41	−17	34	145	4	P	Do.
			6766	+11	85	+12	22	145	9		
			6758	+19	93	−5	19	679	12		
			6765	+34	108	+19	42	24	3		
			6756	+57	131	+10	60	194	2		
			6762	+70	144	−8		218	4		
					(74)	(−7)	71	1,405	34		
Mar. 4	10	53	6768	−74	347	−11	75	291	4	G	U. S. Naval.
			6769	−71	350	−8	72	6	1		
			6767	−61	0	−7	61	24	1		
			6763	−21	40	−17	23	121	6		
			6766	+24	85	+11	30	315	14		
			6758	+32	93	−5	32	824	35		
			6758	+37	98	−4	38	48	11		
			6756	+70	131	+10	70	388	1		
					(61)	(−7)		2,017	73		
Mar. 5	10	59	6769	−68	340	−8	69	12	5	VG	Mt. Wilson
			6768	−61	347	−12	61	436	35		
			6767	−48	0	−8	48	24	2		
			6763	−7	41	−17	13	145	34		
			6766	+38	86	+11	42	388	40		
			6758	+43	91	−5	43	388	21		
			6758	+49	97	−6	49	582	20		
			6756	+83	131	+10	83	388	2		
					(48)	(−7)		2,363	159		
Mar. 6	12	54	6769	−54	340	−8	54	12	1	VG	U. S. Naval.
			6768	−52	342	−12	52	145	4		
			6768	−47	347	−10	47	170	9		
			6767	−34	0	−8	34	24	1		
			6763	+6	40	−17	13	36	16		
			6766	+52	86	+11	54	412	14		
			6758	+55	89	−5	55	194	6		
			6758	+62	96	−6	62	679	20		
					(34)	(−7)		1,672	71		
Mar. 7	11	26	6770	−57	324	+13	60	12	1	VG	Mt. Wilson.
			6769	−41	340	−9	41	48	9		
			6768	−35	346	−12	35	194	18		
			6767	−22	359	−8	22	48	1		
			6763	+19	40	−18	23	73	4		
			6766	+65	86	+12	67	339	12		
			6758	+68	89	−4	68	194	12		
			6758	+75	96	−5	75	630	6		
					(21)	(−7)		1,538	63		
Mar. 8	11	17	6770	−43	325	+13	47	48	8	G	U. S. Naval.
			6768	−29	339	−11	29	24	8		
			6769	−27	341	−8	27	121	22		
			6768	−21	347	−11	22	194	3		
			6767	−9	359	−8	9	24	1		
			6763	+32	40	−19	34	24	4		
			6758	+82	90	−4	82	242	3		
			6766	+85	93	+12	86	145	1		
					(8)	(−7)		822	50		

POSITIONS AND AREAS OF SUN SPOTS—Con.

Date	Eastern standard time		Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Spot or group	Spot count	Plate quality	Observatory
1940	*h*	*m*		°	°	°	°				
Mar. 9	12	54	6770	−30	324	+13	35	97	9	VG	U. S. Naval.
			6769	−19	335	−9	19	48	14		
			6768	−15	339	−11	15	48	12		
			6769	−12	342	−8	12	194	16		
			6768	−8	346	−11	9	218	4		
			6767	+6	0	−8	6	24	3		
					(354)	(−7)		629	58		
Mar. 10	12	8	6770	−18	323	+13	26	97	5	P	Do.
			(*)	0	341	−12	5	48	4		
			6769	+2	343	−9	3	145	8		
			6768	+6	347	−11	6	194	1		
			6767	+17	358,	−9	17	48	3		
					(341)	(−7)		532	21		
Mar. 11	14	10	6773	−82	245	−7	82	48	2	F	Do.
			6770	−3	324	+12	8	170	9		
			6772	+2	329	−13	6	48	4		
			6769	+17	344	−9	18	121	5		
			6768	+21	348	−11	21	194	1		
					(327)	(−7)		581	21		
Mar. 12	11	54	6773	−67	248	−7	67	48	3	P	Do.
			6770	+11	326	+12	14	242	12		
			6772	+17	332	−13	18	170	11		
			6769	+29	344	−9	29	121	7		
			6768	+33	348	−11	33	145	7		
					(315)	(−7)		726	40		
Mar. 13	11	25	6776	−81	221	+21	84	97	2	VG	Mt. Wilson.
			6773	−60	242	−8	60	48	9		
			6775	−58	244	−11	58	24	8		
			6774	−20	282	−9	20	12	3		
			6770	+25	327	+12	31	145	35		
			6772	+30	332	−14	31	97	27		
			6769	+44	346	−9	44	97	8		
			6768	+47	349	−11	47	97	10		
					(302)	(−7)		617	102		
Mar. 14	11	17	6776	−69	220	+22	73	194	2	F	Do.
			6777	−64	225	−9	64	24	1		
			6773	−47	242	−8	47	145	3		
			6775	−45	244	−9	45	24	30		
			6770	+42	331	+12	45	97	26		
			6772	+45	334	−13	45	12	5		
			6769	+56	345	−9	56	48	3		
			6768	+60	349	−11	60	48	5		
					(289)	(−7)		592	75		
Mar. 15	11	46	6776	−57	219	+22	63	[illegible]	3	G	U. S. Naval.
			6777	−51	225	−9	51	24	3		
			6773	−34	242	−9	34	218	22		
			6775	−26	250	−7	26	12	4		
			6770	+53	329	+12	55	48	9		
			6770	+58	334	+11	61	121	4		
			6769	+70	346	−9	71	48	2		
					(276)	(−7)		677	47		
Mar. 16	12	39	6776	−42	221	+22	49	218	3	F	Do.
			6777	−39	223	−10	39	24	2		
			6773	−20	242	−9	20	145	10		
			6775	−12	250	−7	12	24	4		
			6778	−5	257	−8	6	121	7		
			6770	+70	332	+12	72	291	5		
					(262)	(−7)		823	31		
Mar. 17	11	3	6776	−29	221	+22	41	194	7	VG	Mt. Wilson.
			6777	−18	232	−11	18	6	2		
			6779	−9	241	−14	11	6	5		
			6773	−8	242	−8	8	97	25		
			6775	+2	252	−7	2	6	7		
			6778	+10	260	−10	11	73	15		
			6770	+82	332	+12	83	73	2		
					(250)	(−7)		455	63		
Mar. 18	10	53	6781	−86	151	−9	86	24	1	G	U. S. Naval.
			6780	−78	159	+19	80	485	3		
			6776	−16	221	+23	34	170	1		
			(*)	−2	235	−9	3	24	2		
			6773	+6	243	−9	6	48	4		
			6778	+22	259	−9	22	73	6		
					(237)	(−7)		824	17		

POSITIONS AND AREAS OF SUN SPOTS—Con.

POSITIONS AND AREAS OF SUN SPOTS—Con.

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°				
Mar. 19	11 24	6781	−73	150	−9	74	145	5	G	U. S. Naval.
		(*)	−64	159	+11	66	12	3		
		6780	−64	159	+19	67	461	6		
		(*)	−14	209	+14	18	36	3		
		6776	−3	220	+23	29	242	5		
		(*)	+10	233	−9	11	48	9		
		6778	+36	259	−9	36	24	13		
				(223)	(−7)		968	44		
Mar. 20	11 5	6784	−84	126	+11	85	242	2	G	Do.
		6783	−76	134	+12	78	776	8		
		6781	−59	151	−9	59	145	5		
		6780	−50	160	+19	56	364	11		
		6776	+10	220	+23	31	242	5		
		6782	+25	235	−9	25	170	24		
		6773	+35	245	−7	35	12	1		
				(210)	(−7)		1,951	56		
Mar. 21	11 5	6784	−70	127	+11	73	388	2	VG	Do.
		6783	−62	135	+12	64	776	11		
		6781	−45	152	−10	45	97	6		
		6780	−37	160	+19	46	239	11		
		6776	+23	220	+22	36	194	1		
		6782	+38	235	−10	38	267	19		
		6773	+49	246	−7	49	12	1		
				(197)	(−7)		2,073	51		
Mar. 22	11 23	6786	−87	97	−3	87	48	1	G	Do.
		6784	−58	126	+11	61	388	1		
		6783	−48	136	+12	52	824	10		
		6781	−32	152	−10	32	73	5		
		6780	−23	161	+18	34	243	3		
		6776	+37	221	+22	47	145	1		
		6782	+51	235	−10	51	170	4		
		6773	+64	248	−7	64	12	1		
		6785	+87	271	−6	87	24	1		
				(184)	(−7)		1,926	27		
Mar. 23	12 43	6786	−73	97	−4	73	242	3	F	Mt. Wilson.
		6784	−44	126	+10	48	291	1		
		6783	−33	137	+12	37	824	14		
		6788	−29	141	−9	29	145	3		
		6781	−18	152	−10	18	36	7		
		6780	−9	161	+18	27	97	8		
		6776	+51	221	+22	58	170	1		
		6782	+66	236	−11	66	97	2		
				(170)	(−7)		1,902	39		
Mar. 24	9 51	6791	−76	82	−28	77	12	2	VG	Do.
		6790	−65	93	+12	67	24	1		
		6786	−60	98	−4	60	291	7		
		6789	−48	110	+12	52	73	5		
		6784	−30	128	+10	34	291	2		
		6783	−21	137	+12	28	1,164	22		
		6788	−17	141	−9	17	145	7		
		6781	−9	149	−7	9	24	16		
		6780	+4	162	+17	24	73	10		
		6787	+59	217	+18	64	24	3		
		6776	+64	221	+22	67	97	2		
		6782	+81	239	−12	81	97	3		
				(158)	(−7)		2,315	80		
Mar. 25	11 17	6791	−63	81	−28	64	48	8	G	U. S. Naval.
		6790	−49	95	+11	52	36	3		
		6786	−46	98	−4	46	218	7		
		6789	−32	112	+12	36	61	2		
		6784	−18	126	+10	25	291	1		
		6783	−7	137	+13	21	1,164	25		
		6788	−3	141	−9	4	145	7		
		6781	+6	150	−7	6	48	1		
		6780	+17	161	+17	23	145	10		
		6787	+71	215	+19	75	12	2		
		6776	+78	222	+22	80	145	1		
				(144)	(−7)		2,313	67		
Mar. 26	11 12	6792	−71	60	+9	73	24	1	G	Do.
		6792	−63	68	+9	66	73	3		
		6791	−50	81	−28	53	24	3		
		6790	−37	94	+14	43	24	1		
		6786	−32	99	−4	33	218	2		
		6789	−17	114	+12	25	24	2		
		6784	−11	120	+13	23	73	6		
		6784	−3	128	+10	17	291	1		
		6783	+7	138	+13	21	1,406	30		
		6788	+11	142	−9	11	194	6		
		6781	+19	150	−7	19	6	1		
		6780	+30	161	+17	38	121	8		
		6793	+32	163	−11	32	24	2		
				(131)	(−7)		2,502	66		
Mar. 27	11 11	6794	−73	45	−13	74	339	5	G	U. S. Naval.
		6792	−50	68	+8	53	97	10		
		6790	−22	96	+12	28	24	2		
		6786	−19	99	−5	19	218	3		
		6789	−8	110	+11	21	24	4		
		6789	−1	117	+12	18	12	1		
		6784	+2	120	+13	20	24	4		
		6784	+9	127	+10	19	291	1		
		6783	+20	138	+12	27	1,357	30		
		6788	+25	143	−9	25	97	5		
		6780	+45	163	+17	51	48	6		
		6793	+46	164	−11	46	73	7		
				(118)	(−7)		2,604	78		
Mar. 28	11 9	6794	−61	44	−11	61	339	9	G	Do.
		(*)	−58	47	−4	59	12	2		
		6792	−37	68	+8	42	267	21		
		6790	−10	95	+12	22	36	4		
		6786	−6	99	−5	6	218	3		
		6789	+6	111	+11	19	73	7		
		6784	+22	127	+10	27	242	1		
		6783	+33	138	+12	37	1,261	25		
		(*)	+42	147	−9	42	61	7		
		(*)	+45	150	−7	45	12	4		
		6780	+57	162	+17	63	24	4		
		6793	+60	165	−11	60	48	7		
				(105)	(−7)		2,593	94		
Mar. 29	11 0	6794	−48	44	−12	48	315	13	G	Mt. Wilson.
		6796	−48	44	−11	48	48	6		
		6792	−25	67	+7	30	388	30		
		6790	−2	90	+12	19	12	3		
		6786	+7	99	−5	7	242	12		
		6789	+15	107	+12	24	12	3		
		6784	+34	126	−11	39	242	2		
		6783	+46	138	+12	50	1,261	28		
		6788	+56	148	−9	56	48	3		
		6793	+71	163	−11	72	36	2		
				(92)	(−7)		2,604	102		
Mar. 30	12 55	6795	−35	42	−11	35	48	4	F	Do.
		6794	−34	43	−12	34	291	7		
		6792	−12	65	+7	18	291	30		
		6786	+21	98	−5	21	242	2		
		6784	+48	125	+11	53	242	2		
		6783	+59	136	+12	62	1,261	15		
		6788	+70	147	−9	70	36	3		
				(77)	(−7)		2,411	63		

Mean daily area for 30 days=1,518.

*Not numbered.

VG=very good; G=good; F=fair; P=poor.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR MARCH 1940

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich Switzerland]

March 1939	Relative numbers	March 1939	Relative numbers	March 1939	Relative numbers
1	*Ec* 91	11	*a* 48	21	*d* 85
2	*b* 74	12	*Mc* 76	22	*Ec* 92
3	*Mcd* 96	13	74	23	*Ecd* 111
4	116	14	*d* 76	24	115
5	*Ec* 92	15	49	25	*a* 101
6	—	16	*Mc* 70	26	*Ecb* 108
7	77	17	*a* 43	27	*ad* 136
8	*Ec* 72	18	*Mc* 56	28	125
9	*aa* 46	19	*a* 78	29	*a* 98
10	—	20	*d* 79	30	86
				31	*a* 85

Mean, 29 days=84.7

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central-circle zone.
d=Entranceof a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By B. FRANCIS DASHIELL

Resultant-wind directions in the lower levels of the upper air showed marked northerly and northwesterly tendencies over all areas east of the Rocky Mountains and north of the 35th parallel, where mean surface temperatures were decidedly below normal. Elsewhere, and particularly in the far Northwest, the resultant winds were southerly and southwesterly, and mean temperatures much higher than normal. Precipitation was excessive in northern California and the far Northwest, where southwesterly winds prevailed during March. These resultant winds, controlled to some extent by the position of the Aleutian LOW, were largely composed of greatly modified Polar Pacific air and Tropical Pacific air.

Heavy rainfall in the Rio Grande Valley of Texas occurred in association with predominately southerly and southeasterly upper-air resultant winds and moist Tropical Gulf air (chart VIII). The heavy precipitation in New England and the northern Plains States occurred in areas where resultant winds, shown on charts VIII, IX, X, and XI, were definitely from the northwest quadrant. However, during the periods when precipitation occurred, southerly winds were indicated by the upper-air isobars.

Mean humidities were high almost generally except in the Southwest, where El Paso, Tex., Phoenix, Ariz., and Oklahoma City, Okla., reported low monthly means. At Oklahoma City, Okla., where March rainfall was but 1 percent of normal, the average mean relative humidity of all levels was 41 percent, while northward, where precipitation was 150 percent of normal, the Omaha, Nebr., average mean humidity was 68 percent.

Surface temperatures over the country during March were divided nearly equally along the ninety-fifth meridian, with subnormal means to the eastward and above-normal means to the westward. In those areas where resultant-wind directions were decidedly northwesterly it was noted that below-normal surface mean temperatures occurred. Also, these wind directions were more northerly than normal, being outstanding as far south as Nashville, Tenn., at 1.5 kilometers, and Atlanta, Ga., at 3 kilometers. In the West, where mean temperatures were above normal, the resultant directions at 1.5 kilometers were more southerly than normal, especially at Oakland, Calif., and Medford, Oreg. Resultant velocities were greater than normal at 1.5 and 3 kilometers, except over the Southwest and California, where they were less than normal. The largest negative departure from normal was −2.3 meters per second at San Diego, Calif., at 1.5 kilometers, and the greatest positive departure was +3.5 meters per second over Seattle, Wash., at 3 kilometers.

The month showed a slight northward recession of the freezing line at the ground since February. Freezing temperatures (0° C.) covered an area north of a line extending from Lakehurst, N. J., Joliet, Ill., and Bismarck, N. Dak. However, the surface of mean freezing temperature in the free air was found to slope upward rather abruptly until it attained an elevation of 2 kilometers at an average geographical distance of 300 miles south of the location of the freezing line on the ground. The slope of this mean freezing surface then flattened out and intersected the 3-kilometer level along a line that extended from central Georgia, over east-central Texas, southwestern Colorado, to a point north of central California. The maximum height (4,080 meters) above which freezing temperatures occurred was over Miami, Fla., being only 60 meters higher than in the preceding month.

March was generally warmer throughout the upper air below 10 kilometers than during February. However, at Minneapolis, Minn., Joliet, Ill., Sault Ste. Marie, Mich., Buffalo, N. Y., Lakehurst, N. J., and Washington, D. C., lower mean temperatures occurred at most levels than in the preceding month. But in the levels above 10 kilometers, March was colder than February, while at Fairbanks, Alaska (the general source region of Polar Pacific air), March temperatures were lower at all levels.

Mean free-air pressures for March showed some seasonal increases over the preceding month, The magnitude of the March mean pressure gradients for all standard levels was found to increase steadily with altitude from the surface until the difference between the Sault Ste. Marie, Mich., LOW and the Miami, Fla., HIGH reached a maximum of 35 millibars at 7 and 8 kilometers. The steepest mean pressure gradient for any level over the country occurred in the East at approximately 8 kilometers, with the greatest concentration of mean isobars between Lakehurst, N. J., and Charleston, S. C. However, steep mean pressure gradients were also particularly outstanding over Virginia and North Carolina at 10, 11, and 12 kilometers, and strong resultant-wind velocities (table 2) occurred in this area, with the highest speed (36.1 meters per second) over Greensboro, S. C., at 10 kilometers.

MONTHLY MEAN ISENTROPIC CHART [1]

The mean isentropic chart $\theta=298°$ (chart XII) for March 1940, is characterized by a rather uniform south-north moisture gradient over most of the country, but with considerably warmer and moister air prevailing over the West than over the East. The departures of precipitation over the northern part of the country correspond fairly well to this pattern, except for the large excesses over the North Atlantic States. It will be noted that the boundary between positive and negative departures is almost coincident with the position of the "nose" in the moisture lines.

Strong west-northwest flow is seen to predominate over most of the country, with the northern tips of anticyclonic eddies indicated over Florida, Arizona, and Texas.

[1] Prepared by the Division of Research and Education.

TABLE 1.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in ° C., and relative humidities (R. H.) in percent, obtained by airplanes and radiosondes during March 1940*[1]

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1620 m) Number of obs.	P	T	R. H.	Atlanta, Ga. (300 m) Number of obs.	P	T	R. H.	Billings, Mont. (1,089 m) Number of obs.	P	T	R. H.	Bismarck, N. Dak. (505 m) Number of obs.	P	T	R. H.	Boise, Idaho (864 m) Number of obs.	P	T	R. H.	Buffalo, N. Y. (220 m) Number of obs.	P	T	R. H.	Charleston, S. C. (14 m) Number of obs.	P	T	R. H.
Surface	31	835	7.9	39	31	980	7.2	76	31	889	2.0	72	31	957	−5.2	91	31	916	5.4	73	31	988	−3.9	84	31	1,014	9.1	81
500					31	957	7.9	70													31	954	−4.8	75	31	957	11.3	66
1,000					31	901	7.3	64					31	899	−4.1	82	31	901	7.6	67	31	894	−7.0	78	31	901	9.5	60
1,500					31	848	6.3	57	31	845	2.1	68	31	844	−5.6	77	31	848	5.8	60	31	838	−7.9	77	31	848	6.8	58
2,000	31	798	8.4	38	31	797	4.2	54	31	794	0.1	67	31	791	−7.2	74	31	797	2.0	61	31	786	−9.6	73	31	798	4.8	52
2,500	31	750	5.1	37	31	749	1.7	52	31	745	−3.0	68	31	742	−8.9	73	31	749	−1.9	63	31	737	−11.5	71	31	751	2.7	49
3,000	31	706	1.2	38	31	704	−0.8	49	31	700	−6.5	70	31	695	−10.4	71	31	703	−5.4	65	31	690	−13.7	66	31	705	0.5	47
4,000	30	622	−6.7	40	31	620	−6.2	44	31	615	−13.4	74	31	610	−15.6	68	31	618	−11.4	55	31	604	−18.9	63	31	622	−5.1	42
5,000	30	546	−13.9	40	31	545	−12.9	41	31	538	−19.9	74	30	534	−22.0	65	30	542	−17.6	60	30	528	−24.5	59	31	547	−11.6	39
6,000	30	478	−20.9	38	31	478	−20.0	41	31	470	−27.1	70	27	465	−29.0	64	30	473	−24.2	55	30	459	−31.1	57	31	479	−18.5	37
7,000	30	416	−28.7	36	31	416	−27.8	39	31	408	−34.9	66	27	403	−36.8	60	30	412	−32.1	53	30	398	−38.6	54	31	418	−25.9	37
8,000	30	362	−36.4	36	30	362	−35.6	38	31	353	−42.7		25	348	−45.0		30	356	−39.9	53	30	343	−45.4		30	364	−34.0	37
9,000	30	312	−44.1		30	313	−43.4		31	303	−50.2		23	299	−53.1		30	307	−47.6		29	295	−51.2		30	314	−41.6	
10,000	30	269	−51.1		30	268	−50.6		30	260	−56.2		21	255	−59.2		30	263	−54.4		29	253	−54.6		30	270	−49.3	
11,000	30	230	−56.7		29	230	−56.7		30	222	−59.5		19	218	−61.4		29	225	−59.5		26	216	−53.0		28	232	−55.4	
12,000	30	196	−60.0		29	196	−59.1		30	189	−59.7		18	185	−59.7		29	192	−60.9		24	184	−53.2		27	196	−58.7	
13,000	30	167	−59.4		28	167	−58.9		27	161	−57.4		14	158	−57.4		29	163	−59.1		23	157	−52.8		27	169	−59.2	
14,000	28	142	−59.9		28	142	−60.4		26	137	−56.5		11	134	−56.6		28	139	−57.3		21	134	−53.1		26	144	−60.8	
15,000	25	121	−61.6		28	121	−62.8		25	117	−56.6		9	114	−56.9		25	118	−57.3		21	114	−53.5		23	123	−62.7	
16,000	22	103	−63.0		26	103	−64.2		22	100	−56.6		8	98	−56.9		19	101	−58.4		19	97	−54.1		21	104	−64.9	
17,000	19	87	−63.1		20	87	−64.1		15	85	−56.5						13	86	−58.2		11	82	−54.1		19	88	−65.8	
18,000	12	74	−62.9		16	74	−62.8		7	73	−56.3						5	73	−57.4						13	75	−65.4	
19,000					7	63	−60.5																		8	64	−63.6	

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Denver, Colo. (1,616 m.) Obs.	P.	T.	R.H.	El Paso Tex. (1,193 m.) Obs.	P.	T.	R.H.	Ely, Nev. (1,908 m.) Obs.	P.	T.	R.H.	Fairbanks, Alaska (153 m.) Obs.	P.	T.	R.H.	Joliet Ill. (178 m.) Obs.	P.	T.	R.H.	Juneau, Alaska (49 m.) Obs.	P.	T.	R.H.
Surface	31	835	1.6	74	31	880	12.1	32	29	808	0.6	67	31	989	−8.2	60	28	994	−1.3	86	31	1,004	1.6	79
500													31	947	−7.9	62	28	954	−1.6	78	31	949	−0.3	79
1,000													31	888	−9.6	63	28	896	−3.6	78	31	891	−3.3	81
1,500					31	849	13.6	32					31	832	−10.7	65	28	841	−4.2	68	31	836	−6.2	84
2,000	31	796	4.0	64	31	799	10.2	32	29	799	2.1	63	31	783	−13.0	65	28	789	−6.1	64	31	784	−9.2	84
2,500	31	748	1.6	60	31	752	6.4	32	29	751	.9	58	31	730	−15.9	64	28	740	−8.1	62	31	735	−12.1	84
3,000	31	703	−1.9	59	31	707	2.8	32	29	705	−2.9	59	31	682	−18.9	63	28	693	−10.4	63	30	688	−15.3	83
4,000	31	619	−9.1	58	31	624	−4.2	34	20	621	−9.3	55	31	595	−26.0	64	28	608	−15.1	62	29	601	−21.4	78
5,000	31	543	−15.8	57	31	549	−11.3	34	20	545	−15.5	51	30	518	−33.1	62	28	532	−21.3	61	26	524	−28.0	76
6,000	31	475	−22.8	56	31	481	−18.2	33	29	476	−22.8	50	29	448	−39.7	58	28	464	−28.5	61	21	455	−35.0	73
7,000	31	413	−30.8	54	31	420	−26.1	32	28	414	−30.6	48	29	386	−46.2		24	403	−35.5	61	18	393	−41.7	
8,000	31	358	−38.8	53	31	365	−34.1	31	28	359	−38.4	48	27	332	−51.5		23	349	−42.4		16	338	−48.1	
9,000	29	309	−46.6		31	316	−41.6		26	310	−45.8		27	284	−54.2		23	300	−49.1		14	289	−51.7	
10,000	29	265	−53.8		31	272	−49.1		26	266	−53.1		24	243	−53.7		22	257	−55.1		13	248	−51.5	
11,000	27	226	−58.8		31	233	−55.8		26	228	−59.1		24	209	−50.8		22	219	−58.3		11	213	−49.1	
12,000	24	193	−59.6		31	199	−59.8		26	194	−62.4		22	179	−49.4		19	187	−58.5		10	182	−48.2	
13,000	21	164	−58.5		31	169	−59.7		22	165	−60.9		18	153	−49.1		16	159	−56.9		10	157	−47.7	
14,000	20	140	−57.1		30	144	−60.7		22	140	−58.8		18	132	−49.1		14	135	−56.5		8	135	−47.0	
15,000	20	119	−57.3		29	123	−63.2		22	119	−59.8		11	113	−49.2		12	115	−57.6		5	115	−47.4	
16,000	17	102	−57.6		25	104	−65.5		21	102	−60.4						8	98	−58.0					
17,000	13	87	−57.3		19	88	−66.4		14	86	−60.6													
18,000					9	75	−66.9		5	73	−59.8													

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Lakehurst, N. J.[3] (39 m.) Number of obs.	P.	T.	R. H.	Medford, Oreg. (401 m.) Number of obs.	P.	T.	R. H.	Miami, Fla. (4 m.) Number of obs.	P.	T.	R. H.	Minneapolis, Minn. (263 m.) Number of obs.	P.	T.	R. H.	Nashville, Tenn. (180 m.) Number of obs.	P.	T.	R. H.	Norfolk, Va.[3 4] (10 m.) Number of obs.	P.	T.	R. H.	Oakland, Calif. (2 m.) Number of obs.	P.	T.	R. H.
Surface	31	1,010	−0.9	75	31	969	8.5	77	31	1,016	16.9	90	31	986	−5.0	78	31	994	6.8	73	23	1,018	2.9	69	31	1,017	12.3	79
500	31	953	−2.9	75	31	958	8.9	75	31	960	17.1	82	31	956	−5.8	79	31	956	6.5	73	23	958	1.6	62	31	959	10.9	77
1,000	31	894	−4.3	75	31	902	8.3	72	31	905	14.8	75	31	897	−7.1	78	31	900	4.5	71	21	900	−0.8	58	31	903	9.7	64
1,500	31	839	−5.1	73	31	848	5.2	63	31	853	12.9	60	31	841	−7.8	72	31	846	3.1	66	21	845	−2.5	59	31	850	7.4	59
2,000	31	788	−6.5	69	31	798	1.9	65	31	803	11.3	52	31	789	−9.1	66	31	795	1.3	64	20	794	−3.7	57	31	800	5.1	54
2,500	31	738	−8.1	67	31	749	−1.2	62	31	756	9.1	46	31	739	−10.9	62	31	747	−0.8	63	20	745	−5.8	56	31	752	2.2	50
3,000	30	692	−9.9	65	31	704	−3.8	57	31	712	6.4	44	31	692	−13.1	60	31	701	−3.3	62	20	698	−8.4	54	31	707	−0.4	46
4,000	30	608	−14.9	64	30	619	−10.1	52	31	629	0.5	43	30	606	−17.4	58	30	618	−8.8	62	18	614	−13.5	49	31	623	−6.4	45
5,000	29	531	−20.8	60	30	543	−16.2	49	31	555	−5.7	44	30	530	−22.9	57	30	542	−15.1	61	5	538	−20.5	50	31	548	−12.5	45
6,000	29	463	−27.8	55	29	474	−23.0	47	30	488	−12.0	43	30	462	−29.6	56	30	474	−21.7	57					30	480	−19.3	45
7,000	29	401	−35.2	55	29	413	−31.5	46	30	427	−19.2	41	30	400	−37.1	56	30	413	−29.2	56					30	418	−26.8	46
8,000	29	347	−42.3		28	358	−39.5	46	30	373	−26.7	40	30	345	−44.2		30	358	−36.9	57					30	364	−34.9	46
9,000	29	299	−48.9		26	308	−46.8		30	324	−34.2	38	29	297	−50.5		30	310	−44.6						30	314	−43.0	
10,000	29	256	−53.2		22	264	−53.5		30	280	−41.9		27	254	−54.8		30	266	−51.0						30	270	−50.9	
11,000	29	220	−55.1		18	226	−58.8		30	241	−48.9		26	217	−55.9		29	228	−55.9						30	231	−57.8	
12,000	25	188	−54.5		16	192	−61.3		30	207	−54.3		25	186	−54.3		26	195	−58.5						30	197	−62.1	
13,000	23	161	−54.8		13	164	−59.1		30	176	−59.0		25	159	−53.2		24	166	−58.6						30	168	−62.1	
14,000	16	138	−55.3		12	140	−58.4		30	150	−63.3		23	136	−53.3		23	142	−58.9						30	143	−60.3	
15,000	13	117	−56.7		11	119	−58.8		29	127	−66.9		20	116	−53.6		21	121	−60.2						28	121	−60.5	
16,000	11	101	−57.8		8	101	−59.4		29	108	−70.4		12	99	−53.7		20	103	−61.3						27	103	−61.7	
17,000	8	85	−57.3		5	86	−59.8		22	91	−72.8						13	88	−61.9						24	88	−61.9	
18,000									17	77	−73.3						11	75	−61.7						16	75	−61.4	
19,000									12	64	−72.7														13	64	−60.8	
20,000									6	54	−70.9																	
21,000									6	45	−67.7																	

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in ° C., and relative humidities (R. H.) in percent, obtained by airplanes and radiosondes during March 1940*—Coutinued

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)				Pearl Harbor, T. H.[3] [4] (6 m.)				Pensacola, Fla.[3] (24 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	29	968	7.8	65	31	980	0.4	83	31	1,013	18.9	90	30	1,015	13.8	77
500	29	955	8.5	65	31	956	0.3	80	31	958	19.1	75	30	959	12.8	65
1,000	29	899	8.6	56	31	898	−0.9	76	31	904	15.4	76	30	903	11.0	60
1,500	29	846	7.6	49	31	843	−1.7	71	31	852	12.2	73	30	851	9.3	47
2,000	29	796	5.7	44	30	792	−2.8	67	31	802	10.7	59	30	801	7.3	42
2,500	29	748	2.6	42	30	744	−4.7	67	31	755	9.3	41	30	753	5.0	39
3,000	29	703	−1.0	42	30	697	−6.9	66	31	711	7.4	29	30	708	2.5	36
4,000	29	619	−8.1	41	30	612	−12.3	64	30	629	2.5	19	30	625	−3.7	38
5,000	29	544	−14.3	35	29	537	−18.5	61					30	550	−10.2	40
6,000	29	476	−21.8	32	29	469	−25.5	58					28	482	−17.0	42
7,000	28	415	−29.4	31	29	407	−33.3	56					28	421	−24.5	47
8,000	28	359	−37.3	31	28	353	−41.6						28	366	−32.1	51
9,000	28	310	−44.6		28	303	−49.2						28	317	−39.7	56
10,000	28	267	−51.7		28	260	−55.2						25	274	−47.2	
11,000	28	228	−57.8		28	222	−58.4						21	235	−53.3	
12,000	28	194	−60.7		28	189	−58.0						17	200	−57.3	
13,000	28	166	−59.5		26	162	−56.5						14	172	−59.4	
14,000	28	141	−60.4		24	138	−56.0						7	146	−61.9	
15,000	25	120	−62.1		22	118	−57.1						5	123	−65.3	
16,000	23	102	−63.7		20	100	−57.4									
17,000	21	86	−64.1		15	85	−57.7									
18,000	15	73	−63.4		11	73	−57.4									
19,000	5	62	−61.3													

Altitude (meters) m. s. l.	Phoenix, Ariz. (339 m.)				St. Louis, Mo. (171 m.)				San Antonio, Tex. (174 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	31	973	15.2	41	31	995	4.3	73	31	994	14.7	70
500	31	955	19.0	39	31	955	3.7	67	31	957	15.5	68
1,000	31	900	17.0	36	31	898	2.3	65	31	902	14.5	59
1,500	31	849	13.1	35	31	844	.6	65	31	850	12.1	53
2,000	31	799	9.1	37	31	793	−1.2	65	31	800	9.8	50
2,500	31	752	5.4	38	31	744	−3.5	65	31	754	7.4	48
3,000	31	707	2.2	38	30	698	−6.1	65	31	709	4.5	46
4,000	31	624	−3.9	37	30	614	−11.3	58	31	626	−1.9	43
5,000	31	549	−10.9	38	29	538	−17.5	55	31	551	−8.8	41
6,000	30	481	−17.9	38	29	470	−24.7	52	31	484	−16.2	40
7,000	30	420	−25.7	37	28	408	−32.3	49	31	423	−23.8	40
8,000	28	365	−33.6	36	28	354	−40.1		31	368	−31.5	40
9,000	28	316	−41.3		28	305	−47.5		31	318	−39.2	38
10,000	28	272	−48.7		27	261	−53.8		31	274	−46.7	
11,000	26	233	−55.5		27	224	−57.7		31	235	−53.1	
12,000	25	199	−60.1		24	190	−58.0		30	201	−57.9	
13,000	24	170	−60.0		24	162	−56.4		30	172	−58.7	
14,000	22	145	−60.0		22	138	−56.3		29	146	−60.4	
15,000	21	123	−62.1		17	118	−56.8		27	124	−63.0	
16,000	17	105	−64.1		15	100	−57.6		24	106	−65.9	
17,000	9	89	−64.5		10	86	−58.3		19	89	−67.6	
18,000	6	75	−64.4		6	73	−57.3		12	76	−67.6	
19,000									5	64	−65.4	

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	San Diego, Calif.[3] (19 m.)				S. Ste Marie, Mich. (221 m.)				Seattle, Wash.[3] (27 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	30	1,013	14.7	79	31	989	−7.9	82	23	1,014	8.3	83
500	30	957	12.6	71	31	954	−8.2	83	23	958	6.4	76
1,000	30	902	11.0	64	31	894	−10.2	81	23	901	3.6	75
1,500	30	849	9.9	49	31	838	−11.2	80	23	846	0.2	77
2,000	30	799	7.7	41	31	784	−13.1	78	23	795	−2.8	77
2,500	30	751	4.8	34	31	734	−15.4	77	23	746	−5.3	75
3,000	29	707	2.1	34	31	687	−17.5	74	23	700	−7.9	74
4,000	28	623	−4.1	34	31	600	−22.7	72	22	614	−14.0	72
5,000	28	548	−11.1	38	31	523	−28.5	70	22	538	−20.4	75
6,000	28	480	−18.2	46	30	454	−35.3	66	21	469	−27.0	70
7,000	28	420	−25.5	50	29	392	−41.7		20	407	−34.4	68
8,000	25	365	−33.2	52	29	338	−47.4		19	352	−41.8	
9,000	24	316	−41.0		28	290	−51.9		13	303	−48.5	
10,000	24	272	−48.9		28	248	−54.2		10	260	−53.1	
11,000	23	233	−56.6		27	213	−54.1		9	223	−55.4	
12,000	20	199	−61.3		25	181	−53.2		7	191	−55.3	
13,000	18	169	−61.9		23	155	−53.1		6	164	−53.6	
14,000	16	144	−62.8		20	133	−53.1		6	141	−52.9	
15,000	11	122	−64.2		14	113	−53.7		5	120	−52.9	
16,000	6	104	−66.3		5	96	−53.8					
17,000	6	88	−65.6									
18,000	5	75	−65.2									

Altitude (meters) m. s. l.	Shreveport, La.[2] (51 m.)				Spokane, Wash. (598 m.)				Washington, D. C.[3] (7 m.)			
	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.	Number of obs.	P.	T.	R. H.
Surface	18	1,010	10.3	77	31	944	5.3	80	31	1,016	1.9	69
500	18	956	9.6	77					31	955	0.4	66
1,000	18	901	7.8	70	31	899	5.6	69	31	900	−1.2	67
1,500	18	848	6.2	63	31	845	2.3	67	31	843	−3.3	70
2,000	18	798	4.4	57	31	794	−1.2	68	31	791	−4.4	68
2,500	17	750	1.8	56	30	745	−4.7	71	31	742	−6.0	65
3,000	17	704	−0.6	54	30	699	−8.0	72	31	696	−8.0	61
4,000	14	620	−5.8	56	30	614	−13.8	67	31	611	−13.3	62
5,000	11	545	−12.3	54	30	537	−20.1	63	31	535	−19.4	63
6,000	10	477	−19.2	53	30	469	−26.8	59	30	466	−26.4	62
7,000	7	416	−26.4	52	30	407	−34.6	58	28	405	−33.7	58
8,000	6	359	−32.9	54	30	352	−42.3		26	351	−41.1	
9,000					30	303	−49.8		24	302	−48.1	
10,000					29	259	−55.6		21	258	−53.8	
11,000					28	222	−59.3		19	221	−57.2	
12,000					27	189	−58.9		10	188	−59.0	
13,000					25	161	−56.7		7	160	−58.9	
14,000					24	137	−55.6		6	137	−59.2	
15,000					22	117	−55.4					
16,000					20	100	−55.1					
17,000					15	85	−55.2					
18,000					5	73	−54.6					

1 U. S. Army, Patterson Field (Fairfield), Ohio; data for Dayton incomplete.
2 U. S. Army, Barksdale Field, La.
3 U. S. Navy.
4 Airplane observations.

NOTE.—All observations taken at 1 a. m., 75th meridian time, except those at Washington, D. C., Lakehurst, N. J., Norfolk, Va., and Pensacola, Fla., where they are taken before 5 a. m., 75th meridian time. At Pearl Harbor, T. H., observations are taken after sunrise.

None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40.0° C.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (75th meridian time) during March 1940*

[Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)			Albuquerque, N. Mex. (1,554 m.)			Atlanta, Ga. (299 m.)			Billings, Mont. (1,095 m.)			Bismarck, N. Dak. (512 m.)			Boise, Idaho (870 m.)			Brownsville, Tex. (7 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	254	3.5	31	269	3.9	27	283	3.1	29	323	4.2	31	20	1.2	30	318	1.7	29	119	4.4
500							27	282	3.6										29	125	4.3
1,000	31	248	4.3				27	277	4.6				31	347	2.0	30	322	2.2	26	178	1.5
1,500	30	250	4.7				25	285	6.0	29	323	4.3	26	337	4.3	30	284	1.6	22	305	2.2
2,000	28	249	6.7	31	268	4.7	23	283	8.6	28	298	5.2	17	306	8.4	30	269	3.2	20	282	4.7
2,500	27	258	8.1	31	272	4.7	23	282	10.5	27	285	7.2	16	304	11.5	28	272	5.5	19	267	7.3
3,000	27	267	9.6	30	277	5.6	23	278	11.8	26	286	9.3	15	305	11.8	25	266	6.4	19	262	8.6
4,000	24	273	12.3	24	300	10.0	20	288	16.8	19	294	12.7	12	304	14.8	18	286	9.3	18	269	12.8
5,000	22	274	15.2	23	297	15.1	19	284	20.6	14	316	16.6				13	310	12.4	18	262	17.0
6,000	20	280	16.6	23	295	15.6	17	282	23.2	12	315	20.2				10	310	15.3	13	271	17.5
8,000	12	277	18.6	18	291	18.3	15	275	29.1												
10,000	10	276	20.8	15	293	21.5															
12,000				11	278	22.2															
14,000				10	278	22.8															

Altitude (meters) m. s. l.	Buffalo, N. Y. (220 m.)			Burlington, Vt. (132 m.)			Charleston, S. C. (18 m.)			Chicago, Ill. (192 m.)			Cincinnati, Ohio (157 m.)			Denver, Colo. (1,627 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	27	275	4.4	27	291	1.6	28	204	1.4	25	325	2.5	30	278	2.6	30	317	0.5
500	27	258	5.4	27	273	3.6	28	234	4.1	25	330	2.8	30	269	4.5			
1,000	20	268	6.2	27	273	4.5	28	260	6.7	22	289	3.0	26	261	4.4			
1,500	15	276	7.8	21	254	5.4	25	271	7.8	18	276	6.9	23	272	6.9			
2,000	12	286	9.7	15	277	8.5	22	282	11.6	15	287	11.5	19	288	10.9	30	302	1.1
2,500							19	281	12.5	14	291	14.8	18	291	13.7	29	305	2.9
3,000							14	287	13.8	12	298	18.5	16	295	13.9	28	299	5.5
4,000																26	298	8.2
5,000																22	303	11.8
6,000																21	295	14.3
8,000																16	310	18.1
10,000																11	329	19.8
12,000																		
14,000																		

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)			Ely, Nev. (1,910 m.)			Grand Junction, Colo. (1,413 m.)			Greensboro, N. C. (271 m.)			Havre, Mont. (766 m.)			Jacksonville, Fla. (14 m.)			Las Vegas, Nev. (570 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	31	274	3.5	30	289	1.5	30	284	2.5	25	272	2.8	27	290	1.1	29	239	0.3	31	130	1.2
500										25	272	4.4				28	245	2.9			
1,000										22	273	6.0	27	268	3.0	28	256	4.8	31	171	1.0
1,500	31	273	3.6				30	287	2.4	22	282	6.9	27	273	6.6	27	273	6.7	31	226	1.6
2,000	31	271	3.8	30	292	2.2	30	279	2.3	22	291	10.6	24	278	9.9	25	274	8.6	31	254	2.6
2,500	31	266	4.8	30	277	2.4	30	262	1.1	22	289	15.5	19	273	11.1	22	276	10.6	31	270	3.0
3,000	29	276	7.4	30	268	2.8	30	260	3.7	21	285	17.7	18	281	11.0	20	276	13.3	31	280	4.4
4,000	24	284	9.5	25	293	4.3	25	282	6.5	21	289	21.8	11	282	13.5	21	277	16.3	29	296	6.4
5,000	21	275	12.1	20	292	8.2	16	301	9.6	19	286	24.8				20	275	18.3	28	298	10.3
6,000	17	277	12.3	17	287	8.7	12	314	10.3	19	283	29.9				16	274	22.2	27	299	12.1
8,000	10	281	15.3	12	319	11.1				17	276	34.6				12	279	30.2	23	309	14.5
10,000										12	271	36.1							19	306	17.1
12,000																			16	300	19.1
14,000																			11	292	19.2

Altitude (meters) m. s. l.	Little Rock, Ark. (79 m.)			Medford, Oreg. (410 m.)			Miami, Fla. (10 m.)			Minneapolis, Minn. (261 m.)			Mobile, Ala. (10 m.)			Nashville, Tenn. (194 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	30	242	0.1	29	267	0.4	30	125	1.6	27	344	1.4	30	154	2.0	28	298	0.6
500	30	238	1.1	29	239	0.9	30	147	1.6	27	331	2.5	29	219	1.6	28	255	2.0
1,000	27	215	3.8	29	229	1.8	29	228	1.5	24	315	4.2	27	285	3.2	26	265	4.4
1,500	26	237	5.9	29	223	3.0	28	255	2.7	24	313	5.8	26	293	5.9	21	274	6.6
2,000	24	259	8.1	27	217	3.9	24	260	3.3	19	314	5.2	24	299	8.0	16	292	9.1
2,500	23	276	9.4	21	231	2.5	23	271	5.6	19	307	8.2	23	282	9.0	15	291	11.6
3,000	22	287	10.5	18	258	1.9	22	272	7.3	16	304	10.8	22	284	9.6	13	297	15.6
4,000	21	281	16.6	15	273	2.0	21	274	10.9				19	280	13.5			
5,000	13	292	16.2	14	292	4.6	19	272	14.0				13	275	17.7			
6,000				11	312	8.5	18	269	17.6									
8,000				10	311	12.0												
10,000																		
12,000																		
14,000																		

Altitude (meters) m. s. l.	New York, N. Y. (15 m.)			Oakland, Calif. (8 m.)			Oklahoma City, Okla. (402 m.)			Omaha, Nebr. (306 m.)			Phoenix, Ariz. (344 m.)			Rapid City, S. Dak. (982 m.)			St. Louis, Mo. (181 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	26	294	5.7	27	268	3.4	29	230	2.4	31	10	1.4	31	278	1.4	24	5	5.2	29	335	0.7
500	26	291	6.2	27	318	2.0	29	225	2.3	31	24	1.4	31	267	1.9				29	283	1.3
1,000	22	281	8.6	26	340	2.1	29	225	3.7	24	266	2.0	31	256	2.2	24	3	5.4	26	259	2.2
1,500	19	293	13.7	26	318	2.6	28	232	5.4	21	262	4.3	31	258	1.9	23	344	6.5	24	268	5.1
2,000	12	291	15.8	25	308	2.6	28	251	7.9	18	283	6.8	31	251	2.5	19	322	7.9	20	285	7.7
2,500				24	310	4.5	28	262	9.5	15	292	9.5	31	257	3.4	16	310	8.6	18	293	11.7
3,000				24	286	3.7	26	268	11.0	15	289	12.3	30	271	4.7	16	307	10.2	12	286	13.2
4,000				23	294	5.4	22	273	13.6	12	292	15.2	25	293	5.4	11	306	11.9			
5,000				19	285	9.2	20	277	15.4	11	297	19.3	20	304	6.7						
6,000				15	274	8.9	18	279	16.4	10	300	21.0	15	309	8.4						
8,000							12	280	18.9				10	290	7.1						
10,000																					

Altitude (meters) m. s. l.	San Antonio, Tex. (183 m.)			San Diego, Calif. (15 m.)			Sault Ste. Marie, Mich. (230 m.)			Seattle, Wash. (14 m.)			Spokane, Wash. (603 m.)			Washington, D. C. (10 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	30	192	0.6	27	295	4.3	30	304	4.5	27	223	2.8	30	217	2.5	28	296	3.0
500	30	196	0.5	27	308	3.3	30	308	5.6	27	209	3.5				28	298	4.7
1,000	28	210	0.6	22	319	1.6	26	328	4.9	25	201	4.6	30	213	3.8	27	270	7.5
1,500	27	249	2.1	20	7	1.5	23	344	4.8	23	210	5.5	29	229	4.5	25	272	10.1
2,000	26	258	5.1	20	322	3.6	20	335	5.5	18	227	4.9	29	245	6.0	20	273	12.2
2,500	24	264	8.0	18	305	5.1	17	322	6.0	16	250	4.9	24	259	6.2	17	278	17.8
3,000	24	266	10.1	17	288	6.9	16	310	7.6	12	270	7.6	20	259	7.3	12	272	20.6
4,000	22	270	13.2	16	290	6.3	14	304	10.3				14	290	11.9			
5,000	21	273	16.0	14	295	6.0												
6,000	20	276	18.2	12	307	6.3												
8,000	16	273	26.6															
10,000	12	271	35.1															

TABLE 3.—*Maximum free air wind velocities, (M. P. S.), for different sections of the United States*

[Based on pilot balloon observations during March 1940]

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	45.6	W	1,720	25	Boston, Mass	50.8	W	4,340	21	Harrisburg, Pa	60.0	W	6,840	21	Albany, N. Y.
East-Central [2]	48.8	NW	2,440	10	Washington, D. C.	48.8	NW	4,920	25	Cincinnati, Ohio	68.0	WNW	11,640	1	Greensboro, N. C.
Southeast [3]	37.0	WNW	2,500	15	Charleston, S. C	40.8	WNW	3,040	15	Spartanburg, S. C	70.0	WNW	10,260	9	Miami, Fla.
North-Central [4]	40.1	W	1,370	29	Detroit, Mich	50.8	NW	4,930	22	Fargo, N. Dak	80.0	NW	7,730	22	Fargo, N. Dak.
Central [5]	35.6	SSW	2,490	28	Springfield, Mo	47.0	WNW	3,580	23	Indianapolis, Ind	55.0	WNW	8,320	30	Omaha, Nebr.
South-Central [6]	32.2	WNW	2,500	6	Amarillo, Tex	48.6	W	4,090	6	Amarillo, Tex	66.0	WNW	13,310	5	Abilene, Tex.
Northwest [7]	28.2	W	1,750	14	Havre, Mont	33.9	W	3,770	30	Butte, Mont	55.0	NNW	10,380	11	Medford, Oreg.
West-Central [8]	31.2	NNW	2,270	6	Pueblo, Colo	40.6	WNW	4,880	5	Ely, Nev	72.0	WNW	8,410	8	Redding, Calif.
Southwest [9]	30.6	W	2,500	6	El Paso, Tex	41.6	WNW	4,960	6	Albuquerque, N. Mex.	66.0	WNW	[10]35,180	23	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and Northern Ohio

[2] Delaware, Maryland, Virginia, West Virginia, Southern Ohio, Kentucky, Eastern Tennessee and North Carolina.

[3] South Carolina, Georgia, Florida and Alabama.

[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.

[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.

[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and Western Tennessee.

[7] Montana, Idaho, Washington, and Oregon.

[8] Wyoming, Colorado, Utah, Northern Nevada, and Northern California.

[9] Southern California, Southern Nevada, Arizona, New Mexico, and extreme West Texas.

[10] Data doubtful: Altitude based on assumption 105-gram pilot balloon rose at constant ascensional rate of 280 meters per minute when above an altitude of 990 m. above ground. Balloon observed for 126 minutes. Balloon may have floated at high altitudes thus giving erroneous results.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during March 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*

Potential temperatures ° A	Albuquerque N. Mex.			Atlanta, Ga.			Billings, Mont.			Bismarck, N. Dak.			Boise, Idaho			Buffalo, N. Y.			Charleston, S. C.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299							4	6.8	43.0	1	7.0	46.0	2	6.4	42.5	8	6.8	48.5			
300-309	2	7.0	40.5	1	7.8	43.0	14	8.5	52.0	11	8.7	54.4	5	8.1	49.2	16	8.0	49.8	1	7.9	44.0
310-319	15	9.0	49.0	13	8.6	44.3	18	9.9	57.9	18	9.7	57.4	19	9.6	54.7	25	9.4	55.4	4	8.8	48.2
320-329	23	10.4	55.3	30	10.4	54.8	22	11.0	62.0	13	11.1	63.8	30	10.9	60.6	12	10.7	60.8	17	10.6	56.9
330-339	22	11.9	62.6	18	11.7	61.8	9	11.7	64.1	2	11.9	65.5	13	11.9	64.9	10	11.6	61.4	20	11.4	57.4
340-349	8	12.4	63.2	3	12.1	58.3							2	12.8	66.0	2	11.0	52.5	8	12.0	60.0
350-359	2	13.0	62.0													2	13.0	62.0	2	13.4	63.0
360-369	3	14.0	65.0	4	13.9	64.2													1	14.4	65.0
370-379	1	14.3	61.0	1	13.9	61.0							1	13.6	57.0	1	13.5	57.0	2	14.3	61.5
380-389	3	15.3	65.0	2	15.0	65.5	1	13.5	56.0				1	14.6	60.0	2	13.8	55.0	2	14.6	61.0
390-399	5	15.7	64.6	6	15.8	67.0							1	14.8	60.0	2	14.8	60.0	4	16.0	67.0
400-409	1	16.0	64.0	8	16.2	66.4							2	15.8	63.0	2	15.8	60.5	6	16.5	67.8
Weighted means		11.4	58.1		11.7	57.3		10.1	58.0		9.9	58.6		10.8	58.8		9.9	55.5		12.1	58.8
Mean potential temperature °A. (weighted)	336.2			341.5			318.7			315.8			326.4			323.1			344.9		
Number days with observations	30			30			30			22			30			29			27		

Potential temperatures, °A	Denver, Colo.			El Paso, Tex.			Ely, Nev.			Fairbanks, Alaska			Joliet, Ill.			Lakehurst, N. J.			Medford, Oreg.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299	1	7.6	48.0				1	7.0	45.0	17	6.9	48.1	3	7.5	51.3	1	6.7	44.0	3	7.1	47.0
300-309	5	8.6	52.8				6	7.8	45.5	21	7.9	51.4	5	7.8	46.2	5	8.3	50.4	5	8.2	49.2
310-319	20	8.9	49.0	10	8.5	41.9	7	9.5	55.0	15	9.2	56.3	12	9.4	52.7	16	9.1	53.0	13	9.3	51.6
320-329	29	10.8	59.0	21	10.5	55.3	26	10.8	59.3	4	10.0	57.8	20	10.8	60.9	15	10.2	56.0	13	11.0	62.4
330-339	11	12.0	64.9	30	11.7	60.6	10	12.0	65.4				6	11.4	60.2	8	11.1	57.5	4	12.1	66.5
340-349	2	12.6	65.0	5	12.2	58.2	3	12.5	64.0				1	12.4	65.0	1	13.0	64.0	1	11.7	56.0
350-359				1	12.9	58.0	1	13.0	64.0				1	12.5	58.0	1	12.9	63.0			
360-369	1	12.8	55.0				1	12.7	55.0				1	12.4	52.0				1	13.5	59.0
370-379	1	14.6	63.0	5	14.9	66.2															
380-389	1	14.0	53.0	5	15.6	68.0	2	14.9	63.0				2	13.2	55.0	1	13.6	54.0			
390-399	1	15.6	64.0	4	15.8	66.5	1	15.4	62.2	1	13.5	50.0	1	15.4	62.2	1	15.1	60.0	1	15.4	62.0
400-409	3	15.7	60.0	8	16.6	66.6	4	16.1	63.7	1	14.1	49.0	1	15.9	61.0	2	15.4	60.0	2	15.9	62.0
Weighted means		10.7	56.8		12.1	58.6		11.1	58.9		8.3	52.1		10.4	56.7		10.2	55.0		10.4	56.7
Mean potential temperature °A (weighted)	328.2			344.7			333.2			303.6			327.1			326.7			325.0		
Number days with observations	28			31			27			27			24			27			20		

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during March 1940, classified according to t h potential temperatures (10° intervals between 290° and 409°A.) with which they are identified (based on radiosonde observations)*—Con.

Potential temperatures, °A	Miami, Fla.			Minneapolis, Minn.			Nashville, Tenn.			Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.			Pensacola, Fla.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299				3	6.5	45.6							1	5.9	37.7						
300-309	1	7.2	36.0	9	8.1	48.8	1	8.2	50.0	1	8.2	46.0	1	7.4	43.3	10	7.8	46.6			
310-319	1	8.8	46.0	20	9.3	54.6	12	9.1	49.4	6	9.0	49.3	6	9.1	49.0	21	9.4	54.2	2	10.2	56.5
320-329	7	8.9	36.9	20	10.6	59.7	16	10.4	54.8	21	10.8	59.0	26	10.5	56.3	21	10.7	59.4	4	9.8	49.8
330-339	28	10.9	51.7	2	11.8	65.5	16	11.4	58.6	22	12.0	64.2	17	11.6	61.2	10	11.2	58.5	13	11.2	55.8
340-349	17	12.3	57.5				7	11.8	56.6	9	12.8	64.6	7	12.6	63.9	3	11.9	56.7	2	12.5	60.5
350-359	13	13.2	60.3				2	13.1	61.0	1	12.2	50.0				1	11.6	48.0	1	12.5	57.0
360-369	12	14.4	66.1										2	13.6	61.5	2	12.8	54.5			
370-379	7	15.2	67.9				1	13.8	60.0	2	14.4	62.0	2	14.4	61.0						
380-389	10	16.1	72.3				4	14.7	59.8	1	15.5	66.0	3	14.8	62.3	3	14.5	60.0			
390-399	6	16.8	72.2				3	14.9	58.3	1	15.6	66.0	3	15.6	64.0	2	15.5	60.0	1	16.2	72.2
400-409	6	17.3	73.8	1	14.2	52.0	2	16.4	66.0	5	16.1	63.2	5	16.6	67.4	2	15.4	58.5	1	17.9	79.0
Weighted means		13.1	59.4		9.6	55.4		11.3	56.0		11.9	60.8		11.7	58.7		10.5	55.7		11.5	53.0
Mean potential temperature °A. (weighted)		355.0			317.6			338.4			338.3			340.2			320.0			336.9	
Number days with observations		31			27			27			30			28			29			17	

Potential temperatures °A	Phoenix, Ariz.			St. Louis, Mo.			San Antonio, Tex.			San Diego, Calif.			Sault Ste Marie, Mich.			Spokane, Wash.			Washington, D. C.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299													5	7.1	49.2	4	7.1	47.2			
300-309	2	6.4	32.5	4	8.3	49.8							18	8.0	49.9	8	8.4	51.9	5	7.9	47.6
310-319	5	9.1	48.2	15	9.3	52.8	3	8.2	37.0	1	8.4	39.0	28	9.6	57.6	20	9.2	52.8	13	9.5	54.4
320-329	14	10.8	55.5	20	10.8	59.0	13	10.2	51.9	10	10.8	58.3	6	10.4	50.0	27	10.9	62.1	7	10.2	55.9
330-339	17	11.6	59.4	8	11.4	61.1	27	11.3	55.3	9	11.7	61.2	1	12.4	70.0	7	11.7	63.6	4	11.6	62.0
340-349	6	12.4	60.5	1	12.7	66.0	14	12.3	59.4	7	12.7	64.1									
350-359	2	13.0	62.5	2	12.4	56.0	5	13.5	63.0	1	14.2	68.0									
360-369				1	12.9	59.0	5	13.9	60.6												
370-379	1	13.1	52.0	1	13.1	54.4	4	14.6	65.8				2	12.9	51.2						
380-389	1	14.7	59.0	2	14.0	57.5	4	15.4	66.2							1	13.9	55.0			
390-399	2	15.6	65.0	2	15.1	62.5	9	16.1	66.8	4	16.0	68.2									
400-409	2	16.2	64.5	4	16.0	61.8	6	16.4	66.3				1	15.7	62.2						
Weighted means		11.5	56.8		11.1	57.3		12.6	58.4		12.1	61.3		9.3	54.9		10.0	57.3		9.7	54.6
Mean potential temperature °A. (weighted)		337.4			334.4			350.8			340.6			315.6			318.9			318.2	
Number days with observations		26			26			31			16			28			28			19	

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD, in charge]

By BENNETT SWENSON

The outstanding features during March 1940, from the standpoint of floods, were: First, the occurrence of two major floods in the Sacramento Valley occurring within an interval of approximately a month. The first had its beginning the latter part of February and continued into the first week of March while the second began the latter part of March. A report of the first of these floods appears elsewhere in this REVIEW as a separate article; the second flood will be reported at a later date.

Second, the constant threat during the month of floods in the Northeast due to the presence of considerable snow on the ground. No appreciable flooding materialized until the last of the month when floods developed principally in the Susquehanna and Allegheny River basins.

A number of other floods occurred during the month but were mostly of light to moderate degree.

Precipitation during the month was generally considerably above normal in the upper Mississippi and middle Missouri basins, the central Rocky Mountain region, the Northeast, and the middle Pacific slope drainage area. Temperatures were below normal in the eastern half of the country and above normal in the western half.

St. Lawrence drainage.—Moderate flash floods occurred in the Red Cedar and Flint Rivers during the latter part of March. Persistent cold weather up to March 28 had prevented any appreciable run-off and the streams were abnormally low. A sharp rise in temperature on the 29th melted the remaining snow cover and started the break-up of ice in the streams. Sudden rises in the headwaters and ice jams caused moderate overflow in low places. No appreciable damage resulted but 2 lives were lost.

An ice gorge at Napoleon, Ohio, on the Maumee River, caused flooding when the river backed up to a stage of 13.4 feet at that place on March 5.

Slight flooding occurred on the Sandusky River on March 4–5.

Atlantic slope drainage.—Several rises occurred in the Delaware River Basin during the month resulting in some minor flooding with no appreciable losses.

There were three separate periods of high water in the Schuylkill River namely, on the 4th, 15th, and 31st. In the first period rainfall averaging about 1.25 inches over the basin, together with a snow cover of 3 to 4 inches and of heavy water content over northern portions of the basin, caused streams to rise rapidly but did not reach flood stage.

Heavy rain fell on the 14th and 15th, ranging from 1.50 inches in the south and west sections of the basin to 2.70 inches in the north and east. The river rose rapidly and crested at a stage of 14.2 feet at Reading, Pa., on March 15.

Again on the 30th, heavy rains this time ranging from 1.30 inches over southern portions to 2.30 inches over the northern portions occurred when streams were running high and the ground well soaked. The river approximately reached but did not exceed flood stage in this rise.

At the time of the last rise in the Schuylkill, mentioned above, stages in the Lackawaxen, the Lehigh, and the Delaware River at Trenton, N. J., exceeded flood stage slightly with only little actual damage.

During the first half of the month there was a general increase in the depth and density of the snow cover in the Susquehanna Basin, particularly over the northern portion. Measurements made on March 18 indicated an average snow depth of 16.1 inches and a water content averaging 6.41 inches over the basin above Towanda, Pa. The depth of snow on the ground on March 25 in that portion of the basin below Towanda averaged 6.4 inches.

Temperature conditions moderated on March 28 and heavy rains on the 31st resulted in a rapid rise in the upper portion of the basin to slightly above flood stage. The flooding spread over the lower basin and was one of a series of rises that continued into April; the first rise was generally the most severe of the several rises. A discussion of these floods will be given at a later date. It is interesting to note that after the rainstorm of March 31 the snow depth above Towanda was reduced to an average of 5.7 inches, but the water content still averaged nearly 4 inches.

Slight flooding occurred in the Cape Fear River at Elizabethtown, N. C., and in portions of the Savannah River on about March 17, but no appreciable damage was reported.

East Gulf of Mexico drainage.—Moderate to heavy precipitation over much of this drainage in the form of showers and thunderstorms on the 12th and 13th and rain on the 14th, resulted in some flooding.

Flood stage was exceeded in the Apalachicola River at Blountstown, Fla., where a crest stage of 18 feet occurred on March 19 with only slight damage due to suspension of business.

Moderate flooding in the Black Warrior and Tombigbee Rivers extended from the 13th to the 26th. No appreciable damage occurred in the Black Warrior, or in the Tombigbee above Demopolis, Ala. In the lower Tombigbee a total estimated loss of about $10,500 was reported.

A second and minor rise in the lower Pearl River followed closely the primary rise of February exceeding flood stage at Pearl River, La., by 0.8 foot on March 3. Flood stage was again reached during the month at Monticello, Miss., on March 31. Little damage occurred from these rises.

Upper Mississippi and Missouri Basins.—Ice in the upper Mississippi gradually decreased in thickness and considerable open water appeared by the middle of the month. The ice began moving out at La Crosse, Wis., and Dubuque, Iowa, on March 19, but was still frozen solid in the Lake Pepin area.

Stages in the Missouri continued low quite generally. At Omaha, Nebr., the stage was 2.1 feet on March 1, which is the lowest March stage of record and the mean for the month, 3.5 feet, was the lowest March mean of record.

Ohio River Basin.—The ice gorge that was present in the Allegheny River at Parkers Landing, Pa., during February remained at that point until about March 20 when it moved downstream several miles but still held at West Monterey, Pa., 5 miles below Parkers Landing. The water backed up behind the gorge reaching a stage of 24.9 at Parkers Landing on March 20.

Some additional snow fell over the Allegheny and Monongahela Basins during the first half of the month, but during the latter half there was a gradual decline of the snow depth over these basins except in the northern portion of the Allegheny Basin and over the eastern and southern rims of the Allegheny and Monongahela Basins where considerable snow remained.

Precipitation occurred on the 28th ranging from a trace over the upper Monongahela to over an inch in the middle Allegheny, and less than half an inch over the upper Allegheny. Some of the precipitation was in the form of snow in the higher elevations. The rivers showed small rises on the 29th. On March 30 additional precipitation occurred, ranging from half an inch in the upper Allegheny to 2.25 inches in the central basins and 1.50 inches in the upper Monongahela. About 3 inches of water in the form of snow was present in the upper Allegheny of which about 2 inches melted on March 30–31. A rise resulted in the Allegheny which was the first of a series that continued in April, and, as in the Susquehanna, was the greater rise. The crest stage reached at Pittsburgh in this first rise was 28.5 feet at 10 p. m., March 31. The flood will be discussed at greater length in connection with the later rises at a later date.

Minor rises occurred in a few other tributaries of the Ohio River with slight flooding occurring. The principal rises were in the Scioto River from the 3rd to the 6th, the Little Kanawha, which was slightly above flood stage at Glenville, W. Va., on March 31; the Wabash, which was in moderate flood at points between Bluffton and Terre Haute, Ind., from March 3 to March 7; the Cumberland River, which reached flood stage at Celina, Tenn., on March 31; and the Green River, which exceeded flood stage slightly at Woodbury, Ky., on March 4.

In the Ohio River proper, except for the flooding in the extreme upper reach in the vicinity of Pittsburgh on the last of March, flood stage was exceeded during the month only in the lower portion in the vicinity of Shawneetown, Ill. That station and Dams 47 and 50 reported above flood stages from March 8 to 18, but no losses were reported.

Lower Mississippi Basin.—Slight flooding occurred in the St. Francis River where a crest stage of 22.4 feet was reached at Fisk, Mo., on the 15th. Otherwise the stages in the lower Mississippi and the larger tributaries remained at low levels.

Pacific Slope drainage.—The flood that occurred in the Sacramento Valley late in February developed into one of first magnitude, exceeding that of December 1937 and in some respects surpassed any flood since systematic records have been kept by the Weather Bureau. The total damage for the Sacramento and lower San Joaquin

drainage area in this flood has been estimated at about $6,700,000. A report on the features of the flood appears on pages 71–74 in this REVIEW.

Another major flood was developing in the Sacramento Basin at the close of the month, report of which will be made at a later date.

Slight flooding was reported in the Eel River, the river cresting at a stage of 18 feet at Fernbridge, Calif., on March 30, and in the Long Tom River where two rises occurred, the first reaching a stage of 13 feet on March 1 and the second, 11.4 feet on March 30, both at Monroe, Oreg.

Table of flood losses—March 1940

Drainage and river	Lives lost	Tangible property	Matured crops	Prospective crops	Live stock and other movable farm property	Suspension of business	Total monetary loss
St. Lawrence: Red Cedar	2						
East Gulf of Mexico:							
Apalachicola						$1,000	$1,000
Tombigbee		$3,850			$1,500	5,200	10,550
Ohio Basin: Green River in Kentucky		1,000					1,000
Pacific Slope: Sacramento River [1]	2	2,685,314	$600,020	$2,701,630	569,440	174,650	6,731,054

[1] Feb. 27–Mar. 6.

Table of flood stages during March 1940

[All dates in March, unless otherwise specified]

River and station	Flood stage	Above flood stages—dates: From—	Above flood stages—dates: To—	Crest: Stage	Crest: Date
ST. LAWRENCE DRAINAGE					
Lake Michigan					
Red Cedar:	*Feet*			*Feet*	
Williamston, Mich	6	30	(1)	7.2	30
East Lansing, Mich	8	30	31	8.6	30
Lake Huron					
Flint: Columbiaville, Mich	8	31	Apr. 5	10.1	Apr. 1
Pine: Alma, Mich	6	29	30	6.9	29
		Apr. 1	Apr. 2	6.4	Apr. 1
Lake Erie					
St. Marys: Decatur, Ind	13	3	7	17.3	4
Maumee: Napoleon, Ohio	10	5	6	13.4	5
Sandusky:					
Upper Sandusky, Ohio	13	3	4	14.1	4
Tiffin, Ohio	7	5	5	7.0	5
ATLANTIC SLOPE DRAINAGE					
Lackawaxen: Hawley, Pa	9	31	Apr. 1	12.5	31
Lehigh: Lehighton, Pa	9	31	Apr. 1	11.6	31
Schuylkill: Reading, Pa	11	15	15	14.25	15
Neuse: Smithfield, N. C	13	16	18	14.0	16–17
Cape Fear: Lock No. 2, Elizabethtown, N. C	20	16	18	22.6	17
EAST GULF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla	15	16	24	18.0	19
Black Warrior:					
Lock No. 10, Tuscaloosa, Ala	46	14	16	50.4	15
Lock No. 7, Eutaw, Ala	35	15	20	40.5	18
EAST GULF MEXICO DRAINAGE—con.					
Tombigbee:	*Feet*			*Feet*	
Lock No. 4, Demopolis, Ala	39	15	23	46.1	20
Lock No. 3, Whitfield, Ala	33	(2)	2		
		15	25	47.9	20
Lock No. 2, Pennington, Ala	46	17	23	49.0	21
Lock No. 1, Ala	31	(2)	4		
		17	26	34.0	23
Pearl:					
Monticello, Miss	15	31	31	15.0	31
Pearl River, La	12	(2)	5	[3] 12.8	3
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Zumbro: Theilman, Minn	35	31	(1)	36.4	31
Ohio Basin					
Allegheny:					
Red House, N. Y	10	31	31	10.2	31
Parkers Landing, Pa	20	20	22	24.9	20
Lock No. 8, Mosgrove, Pa	24	31	31	25.0	31
Lock No. 5, Schenley, Pa	24	31	(1)	31.8	31
Lock No. 4, Natrona, Pa	24	31	(1)	29.7	31
Lock No. 3, Acmetonia, Pa	25	31	(1)	29.9	31
West Fork of Monongahela: Clarksburg, W. Va	5	31	31	6.0	31
Youghiogheny: Connellsville, Pa	13	31	31	13.2	31
Little Kanawha: Glenville, W. Va	23	31	31	23.6	31
Little Sandy: Grayson, Ky	15	31	31	18.5	31
Scioto:					
Larue, Ohio	11	2	5	14.3	3
Prospect, Ohio	10	4	6	12.2	5
Chillicothe, Ohio	16	4	6	19.0	5
Licking: Falmouth, Ky	28	3	3	28.8	3
Green: Lock No. 4, Woodbury, Ky	33	3	4	34.4	4
Wabash:					
Wabash, Ind	12	3	5	17.4	4
La Fayette, Ind	11	4	6	16.5	5
Covington, Ind	16	5	7	18.1	6
New: New River, Tenn	18	30	30	18.3	30
Cumberland: Celina, Tenn	28	31	(1)		
Ohio:					
Pittsburgh, Pa	25	31	Apr. 2	28.5	31
Dam No. 47, Newburgh, Ind	38	8	11	38.2	9–10
Shawneetown, Ill	33	8	13	34.1	11–12
Dam No. 50, Fords Ferry, Ky	34	8	14	36.0	11–12
Red Basin					
Sulphur: Ringo Crossing, Tex	20	30	30	21.1	30
Lower Mississippi Basin					
St. Francis: Fisk, Mo	20	14	16	22.4	15
WEST GULF OF MEXICO DRAINAGE					
Rio Grande: Mercedes, Tex	21	27	27	21.0	27
PACIFIC SLOPE DRAINAGE					
San Joaquin Basin					
Mokelumne: Bensons Ferry, Calif	12	Feb 28	1	13.3	Feb. 29
Sacramento Basin					
Stony Creek: St. John, Calif	12	Feb. 28	Feb. 28	13.9	Feb. 28
North Fork of Yuba: Colgate, Calif	14	26	26	14.6	26
		30	30	15.3	30
Feather:					
Oroville, Calif	25	Feb. 27	Feb. 28	25.1	Feb. 28
Nicolaus, Calif	25	Feb. 28	1	26.3	Feb. 29
Sacramento:					
Kennett, Calif	25	Feb. 27	Feb. 29	36.3	Feb. 28
Red Bluff, Calif	23	Feb. 27	1	32.2	Do.
Hamilton City, Calif	20	Feb. 28	1	22.6	Feb. 29
Colusa, Calif	28	Feb. 29	2	29.5	1
Knights Landing, Calif	30	Feb. 28	6	34.0	1
Humboldt Bay Basin					
Eel: Fernbridge, Calif	17.5	30	30	18.0	30
Columbia Basin					
Long Tom: Monroe, Oreg	10	Feb. 27	5	13.1	Feb. 29–Mar. 1
		28	(1)	11.4	30

[1] Continued at end of month.
[2] Continued from preceding month.
[3] Secondary crest, primary on preceding month.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL, in charge]

NORTH ATLANTIC OCEAN, MARCH 1940

By J. H. GALLENNE

Atmospheric pressure.—All ocean areas from which reports were received, with the exception of Julianehaab, Greenland, and Belle Isle, Newfoundland, showed negative departures from normal mean monthly barometric pressures for March 1940. Average pressure values for the month, as in February 1940, were highest over the Gulf of Mexico and lowest over the north-central portion of the Atlantic. (See table 1.)

The pressure readings received from ships at sea ranged from 1,033 to 942.5 millibars (30.50–27.83 inches). The highest pressures were reported on the 28th and 29th from the steamships *Lafcomo* and *Tuscaloosa City*, respectively, both near latitude 33° N., and longitude 29° W. The lowest was observed on the S. S. *Pennland* at 9:30 a. m. of March 16, in connection with an area of low pressure, centered near latitude 47° N. and longitude 37.5° W.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, March 1940*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Julianehaab, Greenland [1]	1,010.3	+5.6	1,030	16	981	27
Horta, Azores [2]	1,012.6	−9.4	1,030	26, 27	997	15
Belle Isle, Newfoundland	1,010.8	+0.6	1,031	15	990	24
Halifax, Nova Scotia	1,009.9	−4.7	1,028	2, 14	983	9
Nantucket	1,012.9	−2.3	1,033	2	994	31
Hatteras	1,015.9	−1.4	1,030	26	996	8
Turks Island	1,015.6	−1.0	1,021	17	1,006	8
Key West	1,016.1	−1.5	1,022	16, 17	1,005	8
New Orleans	1,016.7	−0.6	1,029	15	1,004	7

[1] For 29 days.
[2] For 27 days.

NOTE.—All data based on available observations, departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—The number and intensity of cyclones during March, were much less than in the preceding month, and no winds of hurricane force were reported.

During the first quarter of the month, moderate depressions dominated the central and northern portions of the ocean, causing fresh to strong gales over that area.

The coastal waters between Hatteras and Jacksonville experienced disturbed conditions, arising from a shallow depression, 994 millibars (29.35 inches) centered near Savannah, on the morning of March 8. At the a. m. observation of the following day, this disturbance was located near latitude 34°34′ N. and longitude 69° W. Several vessels in the southerly quadrant of the LOW encountered strong to whole gales during March 9. This depression moved in a north-northeasterly direction for the next three or four days toward higher latitudes, where it could no longer be identified owing to insufficient vessel reports.

The American S. S. *Cathlamet*, bound from Dakar, West Africa to Philadelphia, reported southwest wind force 10 (Beaufort scale) at 2 p. m. of the 9th, near latitude 31.6° N. and longitude 60.2° W., and further:

> That during the lull between high winds the force was between 5 and 8. The wind ranged between west-southwest and north during this period. The sky would cloud over completely in a very short time and clear as readily all during the blow. Occasional very violent squalls would blow with near hurricane force, one could see clear sky at the same time up ahead. There was much rain and lightning.

Chart XIV at the end of this REVIEW, shows weather conditions on the Atlantic at the morning observation (1200 G. M. T.) of March 9. On the morning of March 11, a secondary LOW, in connection with the cyclone just described, formed near latitude 42° N. and longitude 50° W. This depression moved slowly eastward with increasing intensity, and caused generally disturbed and heavy weather over the north-central and the northeastern portions of the Atlantic for the next 6 or 7 days. In connection with the disturbance United States Coast Guard Cutter *Hamilton*, near latitude 35.7° N. and longitude 53.3° W., reported numerous severe squalls during the afternoon and evening of the 12th with winds reaching force 11 (Beaufort scale) on occasions. Her lowest barometer reading of 998.0 millibars (29.47 inches) was recorded at 2 p. m. of that day.

During the remainder of the month the disturbances charted were of moderate intensity.

Fog.—From reports at hand, indications are that less fog than usual occurred near the Grand Banks during the month, but it continued plentiful over the coastal area between Nantucket and Hatteras. However, over the North Atlantic from the Grand Banks eastward there were very few reporting ships.

Thick to dense fog was observed on 6 days during March over the north-central portion of the Gulf of Mexico.

Unusual fog conditions off the north coast of Cuba were noted by the observer on the American Tanker *R. P. Smith*, who reported that from 12:55 to 14:00 G. M. T. of March 20, near latitude 24°25′ N. and longitude 83°30′ W., very thick fog was encountered, which reduced visibility to a few hundred yards, and that the sun was completely obscured at times.

Elsewhere during the month, only scattered observations of fog were noted.

OCEAN GALES AND STORMS, MARCH 1940

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began March	Time of lowest barometer, March	Gale ended March	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Bibb, U. S. C. G.	On station No. 1 out from Norfolk.		35 36 N.	53 18 W.	1	2a, 2	3	998.0	SE	S, 8	NW	NW, 9	S-WNW.
Exochorda, Am. S. S.	Marseille	Boston	41 19 N.	57 06 W.	3	2p, 3	3	991.5	NW	NW, 8	N	N, 9	
Cathlamet, Am. S. S.	Dakar	Philadelphia	24 48 N.	43 18 W.	3	9p, 3	5	1009.0	WNW	WNW, 5	N	SW, 10	
Ingham, U. S. C. G.	Position No. 2 in Atlantic.		37 06 N.	40 48 W.	3	6a, 4	4	986.5	ESE	S, 7	S	ESE, 10	
President Hayes, Am. S. S.	Cape Town	New York	29 06 N.	54 30 W.	3	4a, 4	5	1006.5	NW	W, 8	W	W, 9	NW-W.
Saparoea, Du. M. S.	Amsterdam	do	35 36 N.	50 24 W.	7	11p, 7	8	999.6	S	S, 9	W	S, 9	S-W.
Algonquin, Am. S. S.	New York	Galveston	29 23 N.	77 40 W.	8	10a, 8	9	993.6	SSW	WNW, 7	NNW	NW, 9	None.
Cathlamet, Am. S.S.	Dakar	Philadelphia	31 36 N.	60 12 W.	9	2p, 9	12	994.5	SW	SW, 10	WNW	W, 10	WSW-NW.
Brenas, Nor. M. S.	Maranhao, Brazil.	New York	38 27 N.	72 13 W.	9		10		NNW		NW	NW, 9	
Steel Inventor, Am. S. S.	CapeTown	do	[1]31 40 N.	55 10 W.	9	4a, 10	14	1002.3	SSW	WSW, 7	W	NNW, 9	
E. J. Sadler, Am. S. S.	Boston	New Orleans	30 40 N.	76 00 W.	8	12:15a, 9	9	984.6	SE	NW, 9	NW	NW, 10	
Monfiore, Ital. S. S.	Gibraltar	Florida	[1]27 10 N.	71 17 W.	9	6a, 9	9	996.0	WSW	WSW, 9	NW	WSW, 9	
Manuela, Am. S. S.	San Juan	New York	[1]26 53 N.	68 53 W.	9	9	9	996.5		W, 9		W, 9	
Gulfhawk, Am. M. S.	Las Piedras, Venezuela.	do	26 10 N.	74 40 W.	8	1a, 9	10	996.0	WSW	W, 10	NW	W, 10	
Alaskan, Am. S. S.	New York	Cristobal	31 30 N.	74 18 W.	9	7p, 8	9	990.0	NW	SW, 3	NW	NW, 9	
Cold Harbor, Am. S. S.	Gibraltar	Baltimore	33 59 N.	51 10 W.	11	8a, 14	15	994.0	W	N, 8	NE	W, 9	WNW-N.
Mormacstar, Am. S. S.	Narvik	Boston	65 54 N.	3 00 E.	12	12:10a, 11	12	992.0	NE	ENE, 7	NE	NNE, 9	
Ostende, Belg. S. S.	Antwerp	Gulf ports	35 08 N.	57 50 W.	12	10p, 13	14	997.5	W	N, 8	NNW	WNW, 9	NNW-N.
Hamilton, U. S. C. G.	On station		35 42 N.	53 18 W.	12	2p, 12	13	998.0	W	WNW, 9	NW	WNW, 11	
Ostende, Belg. S. S.	Antwerp	Gulf ports	35 08 N.	57 50 W.	12	10p, 13	14	997.5	W	N, 8	NNE	WNW, 9	NNW-N.
Italia, Nor. M. S.		Port Arthur	41 42 N.	36 54 W.	13	9a, 13	15	974.5	WSW	SSW, 6	N	WSW, 10	
Ingham, U. S. C. G.	Ponta Delgada	Position No. 2	37 42 N.	36 48 W.	13	7p, 13	14	983.6	SSW	SW, 9	SW	SW, 9	None.
Hamilton, U. S. C. G.	On station		35 18 N.	52 24 W.	14	4a, 14	14	992.3	N	N, 8	NNW	N, 9	NW-N.
Jomar, Am. S. S.	Gilbraltar	Baltimore	32 53 N.	32 10 W.	14	2—, 15	16	1001.5	SSW	S, 8-9	WSW	S, 9	None.
Noreg, Nor. M. S.	Naples	Beaumont	28 15 N.	47 36 W.	12	4a, 15	15	999.6	W	W, 9	NW	WNW, 10	
Excello, Am. S. S.	New York	Gibraltar	40 36 N.	41 42 W.	14	4a, 15	15	958.0	NE	NE, 7	NE	NE, 10	
Laurent Meeus, Belg. M. S.	Amsterdam	Houston	32 08 N.	50 12 W.	12	8a, 14	15	963.5	W	WNW, 6	NW	NW, 10	WNW-NW.
Mormacsun, Am. S. S.	Tronhdeim	New York	62 36 N.	8 54 W.	12	12n, 12	13	968.6	NNE	NNE, 7	NNE	NNE, 9	
Excello, Am. S. S.	New York	Gibraltar	40 50 N.	36 35 W.	16	2a, 16	16	991.0	NNE	NNE, 8	N	NNE, 10	
Mormacstar, Am. S. S.	Narvik	Boston	53 06 N.	39 00 W.	16	3a, 16	16	992.5	NNW	NNW, 8	N	N, 9	None.
Mormacsun, Am. S. S.	Trondheim	New York	52 54 N.	39 30 W.	16	9a, 16	16	964.0	N	N, 8	N	N, 10	
Executive, Am. S. S.	New York	Tangiers	[1]39 54 N.	64 00 W.	17	2a, 17	18	1002.5	WNW		W	NW, 8	None.
Hamilton, U. S. C. G.	On station		35 36 N.	52 36 W.	18	11p, 18	18	1014.3	WSW	WNW, 8	WSW	WSW, 8	
Mormacstar, Am. S. S.	Narvik	Boston	44 42 N.	53 18 W.	18	8p, 18	19	980.0	SW	SW, 8	NNW	SW, 8	N-NE.
Veendam, Du. S. S.	Rotterdam	New York	49 42 N.	15 36 W.	18	12—, 18	18	[2]986.0	SSW	W, 8	W	WNW, 9	SW-W.
Pennland, Du. S. S.	Antwerp	do	47 12 N.	37 24 W.	15	9a, 16	19	942.5		NW, 8			
President Polk, Am. S. S.	Gibraltar	do	41 54 N.	44 42 W.	19	8p, 19	20	1004.0	S	SW, 8	WNW	WNW, 9	
Jomar, Am. S. S.	Gilbraltar	Baltimore	32 53 N.	61 20 W.	22	3a, 23	23	1004.0	SSE	S, 8	NW	W, 9	
Exchester, Am. S. S.	Izmir, Turkey	New York	36 00 N.	60 12 W.	22	4a, 23	23	996.5	S	SSW, 9	WNW	S, 9	
Troubadour, Nor. S. S.	Santos	do	37 36 N.	71 30 W.	22	4a, 23	24	1001.6	NW	—, 10	N	NW, 10	
Ingham, U. S. C. G.	On position No. 2.		[1]41 00 N.	60 00 W.	24	6p, 25	25	1001.0	SSW	NW, 5	SW	S, 10	
Alabama, Am. S. S.	Houston	Guantanamo, Cuba.	[1]26 25 N.	90 57 W.	25	2p, 26	26	1015.6	NE		ENE	NE, 8	
Exilona, Am. S. S.	New York	Gibraltar	40 06 N.	49 54 W.		9a, 26		1006.5		S, 7		S, 8	
Frode, Dan. S. S.	Bristol	Norfolk	45 28 N.	37 20 W.	28	11—, 29	29	1008.5	WSW	SW, 8	W	W, 10	None.
Weltevreden, Du. M. S.	Cape Town	Boston	39 26 N.	68 25 W.	30	10a, 31	31	[2]945.7	S	W, 9	WSW	W, 9	
Atlantic, Am. S. S.	Trinidad	New York	36 44 N.	71 20 W.	30	5a, 31	31	1002.5	SW	W, 10	WNW	W, 10	Steady.
NORTH PACIFIC OCEAN													
Canton, Swed, M. S.	Columbia River.	Shanghai	34 22 N.	173 26 W.	[3]29	4p, 29	1	977.3	SSW	SSW, 9	W	W, 11	SSW-W.
Niel Maersk, Dan. S. S.	San Pedro	Yokohama	32 48 N.	172 18 E.	1	11a, 1	1	998.5		W, 10	W	W, 10	
Syoyo Maru, Jap. S. S.	Hakodate	Los Angeles	45 18 N.	167 48 W.	1	1a, 1	2	947.2	WSW	SW, 6	WSW	W, 10	
Hugenot, Am. S. S.	Seattle	Portland, Oreg.	[2]48 30 N.	[2]125 04 W.	1	8a, 1	1	1,005.4	SE	SE, 8	S	SE, 8	SE-S.
Lexa Maersk, Dan. M. S.	Yokohama	Los Angeles	43 10 N.	178 52 E.	1	6p, 1	1	959.0	ENE	N, 11	N	N, 11	NE-N.
Brajara, Nor. M. S.	Shimotsu	San Pedro	42 06 N.	157 00 W.		12 noon	2	975.3		SSW, 9	SSW	S, 10	
Granville, Nor. M. S.	Hong Kong	Los Angeles	35 30 N.	146 48 E.	10	6a, 10	11	994.6	W	WSW, 5	W	W, 11	
Canton, Swed. M. S.	Columbia River.	Shanghai	34 50 N.	148 51 E.	10	10a, 10	11	989.2	WNW	WNW, 7	NW	NW, 11	
Mapele, Am. S. S.	Grays Harbor, Wash.	Honolulu	37 40 N.	140 05 W.	11	4a, 12	12	1,001.5	SE	SSE, 5	SSE	ESE, 8	
Tampa, Am. M. S.	Bayang Point, P. I.	San Pedro	36 19 N.	155 57 W.	11	4a, 12	13	1,010.5	N	N, 9	NNE	NNE, 10	
Manini, Am. S. S.	San Francisco	Honolulu	33 42 N.	133 54 W.	12	4p, 12	12	1,010.5	ESE	S, 8	SE	S, 8	
Michigan, Am. S. S.	Yokohama	Portland, Oreg.	39 12 N.	154 00 E.	11	10p, 10	12	987.1	W	S, 5	WNW	W, 8	
Mapele, Am. S. S.	Grays Harbor, Wash.	Honolulu	34 14 N.	144 01 W.	13	12 noon	14	992.5	SW	SW, 6-7	NW	SW, 8	
Maunawili, Am. S. S.	San Francisco	do	35 30 N.	130 24 W.	14	3p, 14	14	1,010.2	S	S, 8	S	S, 8	S-W.
Makiki, Am. S. S.	Seattle	do	38 30 N.	139 36 W.	14	2a, 14	14	996.5	SW	SW, 6	NW	NW, 9	
San Clemente, Am. S. S.	San Pedro	Balboa	13 50 N.	95 20 W.	14	10p, 14	15	1,003.1	NE	N, 8	N	N, 9	
Michigan, Am. S. S.	Yokohama	Portland, Oreg.	40 10 N.	172 20 W.	16	6p, 16	17	997.3	NNW	NNW, 7	N	N, 9	
Collingsworth, Am. S. S.	Yokohama	Victoria, B. C.	48 12 N.	174 00 E.	16	8p, 16	18	989.5	SE	SE, 9-7	SSE	SE, 12	
Makiki, Am. S. S.	Seattle	Honolulu	24 18 N.	154 06 W.	18	2p, 18	18	1,009.0	W	WSW, 5	WNW	WNW, 9	
Norway Maru, Jap. S. S.	Kobe	Portland, Oreg.	37 15 N.	144 31 E.	22	10p, 22	23	982.3	WNW	WNW, 11	NNW	WNW, 11	Steady.
Michigan, Am. S. S.	Yokohama	do	43 53 N.	143 15 W.	23	2a, 23	24	974.3	W	NW, 2	SSW	SE, 10	
Pres. Coolidge, Am. S. S.	Kobe	Honolulu	33 42 N.	152 42 W.		10p, 24	25	972.6	NW	N, 7	NNW	NW, 9	
Mana, Am. S. S.	San Francisco	do	34 36 N.	30 36 W.		3p, 28		1,008.5		W, 8			
Halstead, Am. S. S.	Hondagua, P. I.	San Francisco	29 34 N.	149 12 E.	28	10p, 28	29	1,014.0		NW, 8			
W. S. Miller, Am. S. S.	San Pedro	Portland, Oreg.	45 00 N.	124 36 W.	29	4p, 29	29	993.2	SSE	S, 8	W	S, 8	S-W.

[1] Position approximate.
[2] Barometer uncorrected.
[3] February.

NORTH PACIFIC OCEAN, MARCH 1940

By WILLIS E. HURD

Atmospheric pressure.—As in February, a low-pressure area of considerable magnitude continued in March to lie over much of the northern part of the ocean. The center of the Aleutian LOW had moved eastward to the western part of the Gulf of Alaska where, at Kodiak, the average pressure was 1,002.1 millibars (29.59 inches), which is 3.3 millibars (.10 inch) below the normal of the month. In the Aleutians a low barometer reading of 962 millibars (28.41 inches) occurred at Dutch Harbor on the 2d. The lowest reading of the month, 947.2 millibars (27.97 inches), was reported by the Japanese Steamer *Syoyo Maru*, on the 1st, near 46° N., 168° W. Unusually low pressures for March occurred at Midway Island and Honolulu, where the averages in both instances were 3.4 millibars (.10 inch) below the normals of the month. The average pressure at Midway Island, 1,014.9 millibars (29.97 inches) was next to the lowest for March during the 25-year period 1916–1940. The lowest average was 1,012.9 millibars (29.91 inches), in March 1928.

Anticyclones moved sporadically across middle and northern Pacific waters, but on the average for the month there were only two high-pressure regions, of small extent, one west of California; the other east of China.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, 1940, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow [1]	1,022.6	+1.6	1,038	18	993	1
Dutch Harbor	1,003.0	−2.8	1,026	11, 12	962	2
St. Paul	1,009.2	+2.4	1,029	14, 18	974	3
Kodiak	1,002.1	−3.3	1,024	18	977	2, 26
Juneau	1,008.8	−5.1	1,028	18	985	26
Tatoosh Island	1,015.2	+0.6	1,033	17	988	26
San Francisco	1,016.9	−1.1	1,029	1	1,006	30
Mazatlan	1,012.3	−0.9	1,015	18, 31	1,008	8
Honolulu	1,013.9	−3.4	1,020	2	1,007	12
Midway Island	1,014.9	−3.4	1,022	8, 27	1,006	1, 24
Guam	1,012.2	−0.3	1,016	26	1,006	12
Manila	1,012.1	+0.9	1,016	26, 27	1,009	9, 20
Hong Kong	1,014.6	−0.6	1,021	1	1,012	16
Naha	1,016.5	+0.6	1,023	23, 27	1,005	19
Titijima	1,016.1	+0.2	1,025	29	1,003	20
Petropavlovsk	1,006.6	−0.5	1,026	12, 14	988	18

[1] For 20 days.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Extratropical cyclones and gales.—Storminess on the North Pacific this month was somewhat spotted. The heaviest gales were reported to the immediate eastward of Japan and in midocean on 6 days. There were several days with fresh to strong gales along the California-Hawaiian routes. Elsewhere gale winds were scattered as to locality.

March opened with a deep cyclone of wide extent over middle waters from Bering Sea to the Tropics. In the 1st a number of ships reported gales, mostly of force 10–11, within the area 32° to 46° N., 163° E. to 157° W., with winds of greatest intensity occurring close to the center of that extensive region. A few minor gales occurred in the storm area on the 2d. Thereafter no high winds were reported from the Pacific until the 10th, when a cyclone of considerable severity appeared close to the eastward of central Japan. On the 10th and 11th, near latitude 35° N., longitudes 146° to 149° E., two ships reported west to northwest winds of force 11, lowest barometer 989.2 millibars (29.21 inches), on the 10th. Lesser gales (force 8–9) continued in the vicinity on the 12th, as the cyclone decreased in energy.

A storm of similar local intensity occurred in the same region during the night of the 22d–23d. At this time the Japanese Steamer *Norway Maru*, east-bound from Kobe, experienced westerly gales of force 11, lowest barometer 982.3 millibars (29.01 inches), near 37° N., 145° E. In the Far Eastern region the only further high winds reported were of force 8 to 9, on the 24th and 28th, in connection with moderate cyclones northeast of the Ogasawara (Bonin) Islands.

In the middle northern waters only a few gales were reported subsequently to the 2d. Among these, specific mention may be made of the stormy weather encountered by the American Steamer *Collingsworth*. The ship entered the gale region, with force 8 winds, on the 16th, near 46° N., 166° E. Late on the night of the 17th the gale had risen to force 11, from east-southeast, near 48° N., 173° E., accompanied by squalls of rain and snow. During the forenoon and early afternoon of the 18th, near 48° N., 174° E., the ship steamed slowly into a southeast hurricane, lowest barometer 989.5 millibars (29.22 inches), with a heavy rain and snow. After nightfall the wind rapidly moderated on shipboard. In the southernmost extension of the area affected by this cyclone on the 18th, near 24° N., 154° W., the American Steamer *Makiki* had a westerly gale of force 9, with only slightly depressed barometer. Elsewhere in the great cyclone, few gales were reported.

From the 9th to the 14th a slow-moving cyclone lay to the north and northeastward of the Hawaiian Islands, where it caused rough weather to shipping between about 30° and 40° north latitude, and about 160° and 130° west longitude. The strongest gales noted were of force 10, occurring on the 10th and 12th, near 36° N., 153° to 156° W. A moderately low barometer of 992.5 millibars (29.30 inches) was read on the American Steamer *Mapele*, near 34° N., 144° W., on the 13th.

Between California and the Hawaiian Islands further gales, of force 8 to 9, occurred on the 26th and 28th. Farther northward, on the 23d, near 44° N. 143° W., the American Steamer *Michigan* had a low barometer of 974.3 millibars (28.77 inches), with light winds, followed to the eastward on the 24th by a southeast gale of force 10 and rising barometer.

Close along the American coast, southerly gales of force 8 occurred on the 1st near the entrance to the Straits of Juan de Fuca, and on the 29th near the mouth of the Columbia River.

Tehuantepecers.—Strong northerly winds occurred in the Gulf of Tehuantepec, as follows: Of force 7 on the 31st; force 8 on the 14th, and force 9 on the 15th.

Fog.—Fog was observed on 2 days along the western part of the northern routes. Within the region 32° to 44° N., 130° to 164° W., fog occurred on 10 days altogether, scattered as to dates and localities. In coastal waters ships reported fog on 6 days off California; on 2 days off Lower California; and on 1 day each in the Gulf of Tehuantepec and off Costa Rica.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE I.—*Condensed climatological summary of temperature and precipitation by sections, March 1940*

[For description of tables and charts, see REVIEW, January 1940, pp. 32 and 38]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	55.4	-0.6	2 stations	86	29	Valley Head	21	25	5.25	-0.50	Wadsworth	10.04	Audalusia	2.40
Arizona	53.6	+1.9	4 stations	95	[1] 21	Bright Angel R. S.	1	13	.22	-.81	Bright Angel R. S.	1.07	21 stations	.00
Arkansas	52.0	-.7	2 stations	88	31	Lead Hill	9	25	2.39	-2.27	Arkansas City	5.44	Oden	.78
California	53.0	+1.7	Palm Springs	100	24	Ellery Lake	-8	3	4.30	+.60	Kennett	20.78	5 stations	.00
Colorado	38.0	+3.3	Lamar	86	31	Dillon	-16	14	1.27	-.04	Kassler	3.77	2 stations	T
Florida	63.1	-2.2	Bushnell	94	29	Mason	24	9	3.53	+.42	Ft. Lauderdale	7.88	Jacksonville	1.05
Georgia	53.9	-2.4	Moultrie	88	29	Blairsville	17	26	4.03	-.77	Cumming	8.13	Brunswick	1.22
Idaho	40.0	+4.2	Riggins	79	21	Island Park Dam	-22	[1] 12	2.36	+.55	Deception Creek	7.58	Fort Hall	.29
Illinois	38.3	-2.5	Mascoutah	87	31	Sycamore	0	23	2.02	-1.14	Grand Chain	4.90	Freeport	.71
Indiana	37.6	-3.1	4 stations	82	31	Plymouth	-8	25	1.89	-1.83	Evans Landing	5.05	Albion	.84
Iowa	31.6	-3.0	3 stations	79	30	4 stations	-2	[1] 15	1.72	-.01	Sioux City	3.30	2 stations	.72
Kansas	44.7	+1.2	Medicine Lodge	96	31	Norton	8	14	1.31	-.13	LaCygne	3.83	Coldwater	.06
Kentucky	43.9	-2.1	2 stations	81	31	St. John	11	25	5.02	+.29	St. John	7.33	Uniontown	2.08
Louisiana	60.6	-.1	Cheneyville	89	12	7 stations	28	[1] 9	3.41	-1.24	Ville Platte (near)	6.15	Hackberry (near)	.89
Maryland-Delaware	38.3	-4.4	Cumberland, Md	75	18	2 stations	5	12	3.92	+.32	Wilmington, Del	6.20	Luke, Md	2.46
Michigan	24.8	-4.7	Eau Claire	67	30	Watersmeet	-27	11	1.45	-.66	Deer Park	4.29	Vanderbilt	.33
Minnesota	21.6	-4.9	Rochester	67	30	Warroad	-25	[1] 22	1.93	+.75	Canby	4.05	2 stations	.44
Mississippi	56.5	-.5	2 stations	87	12	4 stations	23	[1] 9	4.55	-1.16	Duck Hill	7.03	Pelahatchee	2.53
Missouri	43.1	-.9	3 stations	89	31	Licking (near)	0	25	2.44	-.80	Centerville	5.23	Grant City	.97
Montana	35.9	+4.7	Forsyth	72	16	Hebgen Dam	-21	12	1.01	+.02	Hebgen Dam	3.86	Sun River Canyon	.17
Nebraska	37.9	+1.3	2 stations	88	31	Nanzel (near)	-9	14	1.58	+.47	McCook	3.99	Watertown	.17
Nevada	43.8	+3.3	Overton	98	24	Marlette Lake	-2	13	.92	-.07	Lewers Ranch	6.10	3 stations	.00
New England	28.2	-4.0	Plymouth, Mass	67	30	First Conn. Lake, N. H.	-22	2	4.22	+.84	Lake Konomoc, Conn.	6.79	Portsmouth, R. I.	2.03
New Jersey	34.7	-4.5	2 stations	72	31	3 stations	8	[1] 12	5.14	+1.37	Charlotteburg	7.47	Barnegat City	3.04
New Mexico	45.2	+1.4	Tatum	91	31	Eagle Nest	-12	5	.56	-.19	Bateman's Ranch	2.61	21 stations	.00
New York	26.3	-5.8	Walden	68	31	3 stations	-20	[1] 2	4.36	+1.28	Hoffmeister	7.86	Fredonia	1.58
North Carolina	47.0	-3.0	3 stations	81	[1] 19	Mount Mitchell	-1	25	3.12	-1.16	Highlands	6.16	Willard	1.52
North Dakota	23.1	-.7	Energy	64	16	Edmore	-26	25	.87	+.11	Carson	2.57	Epping	.17
Ohio	35.3	-3.5	2 stations	79	29	2 stations	2	24	2.96	-.46	2 stations	4.91	Greenville	1.42
Oklahoma	53.2	+2.2	8 stations	98	31	Boise City	14	13	.46	-1.71	Idabel	3.13	14 stations	.00
Oregon	44.4	+3.4	Hay Creek	85	21	2 stations	6	[1] 10	3.64	+.84	Valsetz	17.57	Andrews	.70
Pennsylvania	32.4	-5.2	2 stations	76	29	Kane	-13	12	4.89	+1.36	Mount Pocono	10.55	Grove City	1.36
South Carolina	51.6	-3.2	do	88	[1] 17	Caesars Head	14	25	3.38	-.45	Walhalla	7.08	Rimini	1.81
South Dakota	29.9	-1.4	do	79	[1] 30	McIntosh	-10	23	1.75	+.64	Wentworth	3.84	Ludlow	.44
Tennessee	47.4	-2.1	Union City	84	31	Greenville (near)	-2	25	5.77	+.39	Rock Island	9.96	Memphis	2.51
Texas	59.5	+1.0	2 stations	102	1	Muleshoe	9	[1] 14	1.11	-.92	Hidalgo	5.90	18 stations	.00
Utah	42.0	+3.6	St. George	86	24	Silver Lake	-5	[1] 12	1.24	-.18	Great Basin Experiment Station.	4.75	Emery	.00
Virginia	42.3	-3.5	Hopewell	83	31	Burkes Garden	-1	26	2.58	-1.10	Pennington Gap	5.82	2 stations	1.60
Washington	45.4	+4.0	Touchet	79	15	Stockdill Ranch	10	11	4.12	+.67	Wynoochee Oxbow	16.86	do	.30
West Virginia	38.8	-3.7	6 stations	79	[1] 29	Pickens	-3	[1] 25	3.70	-.23	Pickens No. 2	6.10	do	1.50
Wisconsin	23.8	-5.4	3 stations	69	30	Long Lake	-27	11	1.25	-.48	River Falls	3.13	Brillion	.30
Wyoming	34.3	+4.4	Lagrange	78	31	West Yellowstone	-29	12	1.05	-.11	Beckler River	6.81	2 stations	T
Alaska (February)	14.8	+7.9	Craig	58	1	Wiseman	-39	10	1.19	-.73	Latouche	14.10	do	T
Hawaii	70.4	+1.1	2 stations	90	[1] 7	Kanalohuluhulu	35	[1] 20	5.73	-2.90	Power House (Wainiha).	19.57	Makaweli	.68
Puerto Rico	74.0	+.6	Utuado	96	24	2 stations	50	5	2.15	-1.42	La Mina (El Yunque).	7.44	2 stations	.00

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau Stations, March 1940*

District and station	Elevation of instruments			Pressure			Temperature of the air											Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							30.4	−2.3										73	3.74	+0.3										5.8		
Eastport	75	67	85	29.74	29.83	−0.10	28.9	0.0	49	29	35	7	2	23	24	26	21	74	2.70	−1.1	11	12.6	nw.	42	e.	22	8	7	16	6.3	13.6	T
Greenville, Maine	1,070	6																														
Portland, Maine	103	82	117	29.74	29.87	−.09	30.4	−1.4	57	31	37	7	24	24	27	26	20	69	5.34	+1.5	10	9.1	n.	33	se.	15	16	5	10	4.5	11.1	0.0
Concord	288	58	72	29.50	29.89	−.11	30.1	−.7	58	31	39	−2	2	22	35	25	20	74	3.40	+.4	11	7.2	nw.	25	w.	23	10	10	11	5.4	14.6	3.0
Burlington	403	11	48	29.45	29.91	−.09	24.8	−4.3	49	31	32	−7	2	17	39	22	17	75	3.22	+1.2	14	8.5	w.	32	s.	29	7	5	19	7.2	17.1	T
Northfield	876	12	60	28.92	29.91	−.09	23.3	−3.1	56	31	33	−13	2	14	42	21	17	79	3.23	+.7	19	7.5	n.	23	n.	12	5	7	19	7.2	21.7	8.0
Boston [1]	125	106	165	29.85	29.88	−.09	33.1	−2.5	60	31	40	14	24	27	24	28	21	64	3.83	+.3	11	12.9	w.	34	w.	23	11	9	11	5.5	.3	.0
Nantucket	12	14	90	29.88	29.89	−.09	33.8	−1.7	57	30	39	18	12	28	16	30	26	76	2.39	−1.4	12	15.9	w.	41	se.	15	8	13	10	5.6	.6	.0
Block Island	26	11	46	29.88	29.91	−.07	32.8	−2.6	54	31	38	16	12	28	18	30	25	75	2.92	−.9	12	18.3	w.	43	w.	23	13	11	7	4.5	1.3	.0
Providence	62	215	251	29.84	29.91	−.07	33.3	−2.4	60	31	40	14	12	26	25	28	24	74	3.69	+.2	12	13.7	nw.	40	nw.	25	12	10	9	5.1	3.0	.0
Hartford	159	122		29.90	29.92	−.07	31.2	−3.8	61	31	38	12	2	24	24	27	22	72	5.10	+1.2	15	9.7	nw.	28	nw.	11	6	10	15	6.5	5.9	.0
New Haven	13	74	68	29.93	29.94	−.05	33.1	−2.7	64	31	40	13	12	27	22	29	24	74	5.36	+1.3	14	9.6	nw.	29	e.	15	8	12	11	5.8	4.9	.0
Middle Atlantic States							37.5	−3.2										67	3.83	+0.4										6.6		
Albany [1]	292	26	40	29.60	29.93	−.08	26.8	−5.9	58	31	34	−4	2	20	33	23	18	71	4.53	+1.9	16	11.9	nw.	35	w.	10	3	8	20	7.5	9.6	T
Binghamton	871	57	79	29.00	29.96	−.06	28.3	−4.3	56	31	34	5	12	22	28	25	21	75	4.87	+2.2	17	7.7	nw.	27	nw.	20	1	9	21	8.1	13.1	T
New York	314	415	454	29.59	29.94	−.06	35.0	−2.7	60	31	42	15	24	28	19	30	22	62	4.47	+.8	14	17.6	nw.	49	se.	15	8	10	13	6.2	3.3	.0
Harrisburg [1]	374	94	104	29.59	29.98	−.05	35.4	−3.5	66	31	42	16	24	29	28	30	24	67	4.99	+2.0	11	10.7	nw.	36	s.	20	4	9	18	7.2	2.9	.0
Philadelphia	114	174	367	29.84	29.97	−.05	37.5	−3.3	66	31	44	18	24	31	24	32	24	63	4.10	+.7	10	13.9	nw.	42	se.	14	5	12	14	6.5	3.2	.0
Reading	323	283	306	29.61	29.98		35.8	−4.2	64	31	42	15	24	29	26	31	23	62	4.17	+.6	12	14.5	nw.	45	s.	20	7	9	15	6.5	3.5	.0
Scranton	805	72	104	29.07	29.96	−.06	30.8	−4.9	56	31	37	8	12	25	26	27	21	69	6.52	+3.3	16	7.5	nw.	27	nw.	20	4	8	19	7.3	10.5	.0
Atlantic City	52	37	172	29.91	29.97	−.05	37.2	−1.4	67	31	44	17	12	31	25	32	26	68	4.60	+1.0	11	17.1	w.	56	se.	15	4	16	11	6.3	.5	.0
Sandy Hook	22	10	57	29.92	29.95		34.2	−5.1	58	30	40	18	24	29	32	30	26	73	4.32	+.3	12	16.8	w.	43	nw.	25	4	12	15	6.8	1.7	.0
Trenton	190	89	107	29.75	29.96		35.5	−3.6	64	30	42	15	12	29	25	31	24	66	4.72	+1.3	13	11.0	nw.	34	nw.	14	3	13	15	6.9	3.8	.0
Baltimore [2]	16	100	215	29.97	29.98	−.05	40.0	−2.3	68	31	47	19	12	33	25	34	27	66	3.97	+.3	11	12.0	nw.	38	sw.	31	7	11	13	6.6	.8	.0
Washington	112	62	85	29.85	29.98	−.06	40.7	−1.9	70	31	49	19	25	33	33	34	24	56	3.42	−.1	9	8.9	nw.	27	nw.	16	7	12	12	6.4	.4	.0
Cape Henry	18	8	54	29.95	29.97		44.4	−2.2	74	30	52	27	24	37	33	39	34	74	2.45	−1.4	11	12.4	se.	34	n.	22	11	10	10	5.6	4.5	.0
Lynchburg	686	144	184	29.24	30.00	−.05	44.6	−2.7	78	31	54	20	25	35	33	36	27	56	2.07	−1.5	10	9.1	nw.	34	nw.	30	15	7	9	5.0	.9	.0
Norfolk	91	80	125	29.88	29.98	−.05	46.8	−1.4	76	18	55	26	24	38	31	40	35	72	2.05	−1.7	9	10.2	n.	31	w.	16	7	9	15	6.4	4.6	.0
Richmond [2]	164	11	52	29.80	29.98	−.06	44.6	−2.6	78	18	55	20	24	34	36	37	31	68	2.09	−1.6	10	8.9	ne	30	n.	31	12	7	12	5.5	.3	.0
Wytheville	2,304	49	55		29.98	−.07	39.2	−3.1	71	29	48	11	26	30				73	1.73	−1.7	11	8.4	w.	30	nw.	16	7	11	13		3.4	.0
South Atlantic States							52.0	−1.7										72	2.77	−1.0										5.5		
Asheville	2,253	89	104	27.62	30.02	−.04	43.4	−1.5	76	29	53	18	26	33	39	37	32	71	2.85	−1.1	10	9.2	nw.	32	nw.	16	9	9	13	6.0	3.5	.0
Charlotte [2]	769	63	86	29.16	29.99	−.06	48.6	−1.8	75	18	58	22	25	39	35	40	35	71	2.96	−1.2	13	8.0	ne.	26	w.	23	11	8	12	5.8	2.8	.0
Greensboro [1]	886	6	56	29.03	29.99		44.4		74	18	56	14	25	33	43	38	32	70	2.34		10	9.1	ne.	26	sw.	31	10	8	13	5.4	4.3	.0
Hatteras	11	5	50	29.97	29.98	−.06	47.8	−4.2	69	29	54	31	26	42	24	44	41	84	2.49	−1.8	10	12.9	ne.	34	n.	21	10	8	13	5.6	.6	.0
Raleigh [2]	358	103	146	29.60	29.98	−.07	48.4	−1.8	77	18	58	21	25	38	35	41	35	68	3.35	−.5	10	9.5	nw.	31	w.	30	11	11	9	5.1	7.0	.0
Wilmington	72	73	107	29.91	29.99	−.06	52.3	−1.0	77	18	62	26	26	43	28	45	40	73	1.90	−1.3	11	9.8	nw.	28	s.	14	11	9	11	5.3	.0	.0
Charleston	48	11	92	29.95	30.00	−.06	55.0	−2.4	77	19	63	33	26	47	25	49	45	77	2.62	−.4	7	10.4	sw.	27	e.	24	10	10	11	5.8	.0	.0
Columbia, S. C	225	70	91	29.75	29.99	−.07	53.0	−2.2	81	29	64	27	25	42	37	44	38	69	3.01	−.4	10	8.7	ne.	30	sw.	16	10	11	10	5.3	.0	.0
Greenville, S. C.	1,040	70	78	28.88	29.99		49.2	−.7	77	29	60	25	26	39	36	41	34	64	4.29	−.9	11	7.6	ne.	24	sw.	30	9	10	12	5.6	2.0	.0
Augusta [2]	426	62	77	29.53	29.98	−.08	54.4	−1.6	80	17	66	31	26	43	38	45	38	67	3.27	−.8	9	6.4	nw.	24	w.	16	10	8	13	5.7	.0	.0
Savannah [2]	51	73	152	29.94	30.00	−.06	58.2	−.8	80	17	69	35	9	48	32	48	44	75	2.65	−.4	8	11.3	nw.	27	nw.	14	12	7	12	5.2	.0	.0
Jacksonville	43	86	110	29.96	30.01	−.05	61.8	−.8	83	29	72	36	9	52	32	53	48	71	1.05	−1.9	9	8.6	w.	26	w.	30	8	11	12	5.7	.0	.0
Florida Peninsula							68.3	−1.6										80	2.68	+0.7										5.0		
Key West [2]	21	10	64	29.98	29.99	−.06	71.0	−1.6	84	31	76	56	6	66	17	65	63	83	2.72	+1.3	7	10.5	e.	35	w.	8	10	13	8	4.9	.0	.0
Miami	25	124	168	29.98	30.01	−.07	69.2	−1.0	84	31	76	44	10	63	24	63	60	77	3.28	+1.1	7	10.2	se.	37	w.	8	12	9	10	5.3	.0	.0
Tampa [2]	11	88	197	30.00	30.01	−.06	64.6	−2.2	84	29	74	44	10	56	29	58	55	79	2.04	−.4	10	11.1	s.	38	nw.	8	12	11	8	4.7	.0	.0
East Gulf States							56.5	−1.2										74	4.95	−0.3										5.8		
Atlanta [1]	976	5	72	28.96	29.99	−.07	49.8	−2.2	79	31	61	26	25	39	36	43	38	70	5.27		13	11.5	nw.	33	w.	30	10	11	10	5.5	T	.0
Macon [2]	464	79	87	29.49	29.99	−.07	54.2	−2.5	81	29	65	31	9	43	37	46	41	72	3.70	−1.3	13	7.6	nw.	24	n.	24	9	8	14	5.6	.0	.0
Thomasville	273	49	58																													
Apalachicola	35	11		29.97	30.01		59.0	−2.6	76	22	66	37	9	52	27	54	51	82	3.20	−1.0	7	9.1	se.	33	e.	21	7	9	15	6.5	.0	.0
Pensacola	56	54	79	29.95	30.01	−.05	58.6	−1.7	75	22	66	35	9	51	28	53	50	79	6.13	+1.4	10	8.6	se.	27	nw.	7	9	14	8	5.1	.0	.0
Anniston	741	9					52.6	+.1	80	29	64	26	9	41	37				5.23	−.2	12		nw.				14	8	9		T	.0
Birmingham [2]	630	11	48	29.34	30.01	−.05	53.7	−1.7	80	31	64	27	25	44	32	45	40	71	6.46	+.8	14	8.4	n.	29	w.	29	8	13	10	5.8	T	.0
Mobile	29	86	161	29.98	30.01	−.05	59.4	−.3	79	30	68	36	15	50	29	52	49	82	4.19	−1.8	12	10.8	s.	33	nw.	8	7	14	10	5.7	.0	.0
Montgomery [2]	327	92	105	29.75	30.00	−.06	56.6	−1.2	81	29	67	33	9	46	31	48	43	73	5.94	.0	14	8.1	n.	28	sw.	29	7	10	14	6.1	.0	.0
Meridian [2]	310	67	92	29.67	30.00	−.05	56.4	−.7	82	12	68	29	9	45	34	48	44	75	5.57	+.3	9	7.1	sw.	24	nw.	7	5	18	8	5.7	.0	.0
Vicksburg	247	82	102	29.72	29.98	−.06	58.5	.0	85	12	69	30	25	48	31	50	42	60	3.94	−1.6	9	9.8	s.	25	e.	29	8	11	12	6.0	.0	.0
New Orleans [2]	30	76	84	29.97	30.00	−.04	62.8	.0	85	12	72	43	15	54	28	55	51	74	5.10	+.4	10	7.1	se.	24	nw.	8	6	13	12	5.9	.0	.0
West Gulf States							59.6	+0.4										67	1.45	−1.5										5.4		
Shreveport [2]	181	92	227	29.77	29.96	−.06	59.0	+.7	85	31	70	29	25	48	34	50	45	68	2.22	−1.9	6	12.9	s.	45	nw.	12	14	7	10	4.6	T	.0
Bentonville	1,303	12	51	28.61	29.99		48.0	+.7	84	31	59	19	25	37	40				1.72	−2.3	7	9.0	e.	27	se.	6	9	9	13	5.9	2.0	.0
Fort Smith	463	57	82	29.49	29.97	−.04	52.2	−.4	86	31	63	25	14	41	44			58	1.20	−1.8	6	9.9	e.	26	sw.	28	9	12	10		.0	.0
Little Rock [2]	265	94	102	29.70	29.99	−.04	52.4	−.6	84	31	63	27	25	42	40	45	40	72	1.31	−3.3	11	9.5	e.	28	sw.	2	15	4	12	4.6	.0	.0
Austin [2]	605	68	90	29.30	29.96		61.8	+1.1	87	31	73	34	14	51	36	52	45	63	1.36	−.9	6	8.1	s.	35	w.	29	9	11	11	5.6	.0	.0
Brownsville [2]	20	88	96	29.91	29.93		67.8	−.4	88	30	76	46	14	59	26	61	58	79	3.57	+2.3	7	11.9	se.	34	n.	13	5	13	13	6.3	.0	.0
Corpus Christi [2]	44	11	78	29.90	29.95	−.03	65.2	+.2	83	2	72	42	14	58	26	58	55	79	1.57	.0	8	11.6	s.	34	n.	13	8	10	13	5.8	.0	.0
Dallas [2]	488	220	227	29.41	29.93		59.6		87	31	71	32	13	48	34	50	42	58	1.65	−1.2	6	14.0	s.	42	nw.	12	14	12	5	3.8	.0	.0
Fort Worth [2]	706	35	56	29.19	29.94	−.04	60.0	+2.3	94	31	73	31	13	47	38	50	40	54	.40	−1.9	5	14.4	s.	44	nw.	12	11	12	8	4.9	.0	.0
Galveston [2]	9	106	114	29.97	29.98	−.03	61.0	−1.4	77	2	66	42	14	56	25	55	52	82	1.20	−1.5	4	10.6	s.	37	nw.	7	9	11	11	5.5	.0	.0
Houston [2]	62	157	190	29.91	29.98		63.4	+.1	87	30	73	36	14	54	31	55	50	73	.66	−2.8	8	10.8	se.	30	nw.	7	9	8	14	6.1	.0	.0
Palestine	510	64	72		29.97	−.03	60.0	+.9	85	31	71	33	25	49				58	.45	−3.0	2	9.3	s.	26	nw.	7	9	6	16		T	.0
Port Arthur	34	59	134	29.95	29.98		61.8		81	30	70	35	14	53	30				1.99	−1.3	4	12.8	s.	34	nw.	7	7	12	12	6.4	.0	.0
San Antonio [2]	582	111	301	29.34	29.96	−.02	64.0	+1.2	90	31	75	37	14	53	34	55	48	65	.94	−.9	10	11.5	s.	35	n.	13	8	9	14	5.8	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, March, 1940*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
							42.1	−2.1										71	3.71	−0.5										7.0		
Chattanooga [2]	688	71	214	29.27	30.01	−0.05	50.3	−0.9	78	31	59	25	25	42	34	43	38	72	4.98	−0.8	13	9.2	nw.	27	w.	18	9	6	16	6.0	1.6	0.0
Knoxville [1]	980	66	84	28.95	30.01	−.05	47.2	−1.5	77	31	56	18	25	38	35	40	35	71	5.09	.0	9	6.5	ne.	24	nw.	30	11	7	13	5.7	6.1	.0
Memphis [2]	284	78	86	29.68	29.98	−.06	51.6	−.7	79	31	60	26	25	43	31	45	40	73	2.51	−2.8	13	9.0	e.	23	nw.	18	12	6	13	5.8	T	.0
Nashville [2]	605	168	188	29.34	30.00	−.05	47.4	−1.8	81	31	56	21	25	39	31	41	36	71	7.63	+2.5	13	10.0	n.	33	s.	2	9	6	16	6.4	4.5	.0
Lexington	989	6					41.8	−1.9	77	31	51	17	25	33	38				6.07	+1.8	14										2.7	
Louisville [2]	315	106	120	29.41	30.00	−.05	43.1	−2.3	80	31	51	18	25	35	36	37	31	70	5.35	+1.0	9	10.2	nw.	30	sw.	27	13	4	14	5.5	T	.0
Evansville	431	76	116	29.53	30.01	−.03	44.2	−1.7	80	31	52	20	25	36	27	38	32	64	1.75	−2.4	9	10.2	n.	38	s.	2	5	8	18	7.3	.1	.0
Indianapolis [2]	808	98	129	29.10	29.99	−.05	38.0	−2.0	73	17	46	13	25	31	36	32	28	75	.90	−3.0	12	9.0	nw.	28	nw.	20	2	11	18	7.6	.3	.0
Terre Haute	575	63	149	29.36	29.99		40.5		77	31	48	15	5	33	35	34	27	64	1.86	−1.9	12	10.3	nw.	31	sw.	29	3	8	20	7.5	.6	.0
Cincinnati [2]	497	11	51	29.46	30.00	−.05	40.1	−.8	78	31	48	15	25	32	39	35	30	71	3.32	−.6	11	8.9	nw.	28	w.	20	5	7	19	7.5	3.5	.0
Columbus [2]	833	90	110	29.08	29.99	−.05	37.6	−1.5	72	29	45	13	25	30	35	32	28	75	2.65	−.8	15	10.3	w.	39	sw.	20	2	10	19	7.8	4.3	.0
Dayton	900	186	213	29.01	29.99		37.6	−2.9	71	29	45	11	25	30	35	33	27	70	2.64	−1.0	17	10.8	nw.	36	w.	20	5	8	18	7.4	3.4	.0
Elkins [2]	2,006	61	78	27.82	29.98	−.07	36.6	−3.4	72	29	46	5	26	28	39	32	27	76	3.47	−.3	20	8.0	w.	26	sw.	20	3	5	23	8.0	6.2	.0
Parkersburg	637	77	84	29.30	29.99	−.06	40.2	−2.6	78	29	49	14	26	31	40	34	28	68	3.18	−.3	13	7.7	w.	27	w.	20	4	9	18	7.2	1.4	.0
Pittsburgh [1]	1,273	39	54	28.59	29.99	−.05	33.6	−6.0	74	29	42	9	24	25	32	30	25	75	4.18	+1.2	16	12.8	nw.	45	w.	20	2	11	18	7.6	7.9	.0
Lower Lake Region							28.4	−4.4										80	2.83	+0.2										7.5		
Buffalo [2]	706	243	280	29.18	29.97	−.05	27.0	−4.1	50	29	33	6	24	21	26	24	21	83	2.35	−.2	16	16.2	w.	50	sw.	20	4	7	20	7.4	15.7	1.0
Canton	448	10	61	29.42	29.92		21.7	−6.0	50	29	30	−11	13	13	35	20	17	84	3.36	+.9	16	9.3	w.	30	sw.	22	7	9	15	6.7	24.9	2.0
Ithaca	836	11	100	29.02	29.95		27.9	−3.9	55	31	34	5	13	22	33				3.47	+1.2	19	10.5	nw.	32	se.	14	2	8	21	7.9	20.4	T
Oswego	335	71	85	29.57	29.95	−.06	27.0	−4.2	50	31	32	5	13	22	25	24	18	70	2.39	−.2	16	11.7	w.	31	w.	25	4	8	19	7.5	15.8	6.0
Rochester [2]	535	86	102	29.34	29.96	−.06	27.4	−4.4	55	29	33	10	24	22	23	23	20	81	2.92	+.2	22	9.9	w.	29	w.	20	2	12	17	7.5	15.8	T
Syracuse [2]	408	65	79	29.50	29.96	−.06	27.2	−4.4	54	31	33	5	13	21	30	23	21	85	5.42	+2.4	22	8.2	w.	21	nw.	20	3	6	22	8.0	29.3	4.0
Erie	714	57	81	29.18	29.98	−.04	29.2	−4.3	65	29	35	9	24	24	31	27	24	84	2.28	−.3	17	8.7	sw.	26	e.	13	2	9	20	8.0	10.2	.0
Cleveland [2]	805	267	318	29.09	29.99	−.04	31.0	−3.6	74	29	37	9	24	25	31	28	25	81	2.50	−.1	17	14.5	nw.	46	w.	20	3	9	19	7.6	13.4	.0
Sandusky	629	5	67	29.28	29.98	−.05	31.4	−3.7	71	29	38	10	24	25	37				2.38	−.3	11	10.0	nw.	25	w.	20	7	4	20	7.4	9.6	.0
Toledo [2]	628	79	87	29.29	30.00	−.03	30.2	−5.1	67	29	36	10	24	25	32	27	24	80	2.23	−.3	12	11.2	nw.	28	e.	12	6	9	16	6.7	9.4	.0
Fort Wayne	828	69	84	29.08	30.00		32.0	−4.8	67	17	38	11	25	26	33	28	24	79	2.53	−.7	13	10.0	nw.	32	w.	20	3	7	21	7.8	1.4	.0
Detroit [1]	626	5	78	29.30	30.00	−.03	28.6	−4.8	66	29	34	6	24	23	32	26	22	78	2.07	−.3	14	11.6	nw.	30	w.	20	2	10	19	7.6	9.3	.0
Upper Lake Region							25.3	−2.9										78	1.44	−0.7										6.6		
Alpena	609	13	89	29.32	30.01	−.02	24.2	−1.3	57	30	31	3	24	18	27	21	17	74	.60	−1.4	7	12.2	nw.	38	e.	13	6	8	17	6.5	6.8	.0
Escanaba	612	51	72	29.36	30.05	+.01	23.0	−1.2	45	30	31	1	23	15	29	20	17	80	.66	−1.2	8	11.7	n.	28	nw.	19	7	11	13	6.4	5.4	T
Grand Rapids [2]	689	70	244	29.22	30.00	−.03	28.8	−4.6	63	30	34	8	25	23	21	24	21	82	1.92	−.6	13	12.3	n.	55	sw.	29	7	7	17	7.1	19.9	.0
Lansing	878	5	90	29.02	30.00		27.1	−5.1	62	29	34	2	24	20	27	25	22	84	2.07	−.3	11	9.6	nw.	28	sw.	29	7	8	16	6.8	15.4	.0
Ludington	637	60	66																													
Marquette	734	44	69	29.22	30.05	+.01	22.8	−2.0	51	30	28	4	23	17	20	20	17	81	1.02	−1.2	14	8.2	nw.	21	sw.	20	2	10	19	7.5	8.8	9.5
Sault Sainte Marie [1]	724	11	52	29.19	30.02	−.01	19.5	−2.1	44	30	28	−6	23	12	28	17	12	77	1.45		11	9.5	nw.	30	nw.	25	9	9	13	5.9	9.5	2.2
Chicago	673	7	131	29.26	30.01	−.02	32.2	−3.1	69	30	37	9	23	27	26	28	23	72	2.41	−.2	12	11.4	nw.	40	sw.	29	5	7	19	7.6	6.3	.0
Green Bay	617	109	141	29.33	30.03	−.01	25.6	−3.0	58	30	32	5	23	19	23	23	17	69	.66	−1.4	6	11.4	n.	30	s.	29	7	10	14	6.6	7.4	.0
Milwaukee [1]	698	97	221	29.25	30.03	.00	28.8	−3.3	57	30	34	5	23	24	20	25	21	78	2.07	−.4	10	13.9	n.	38	w.	29	7	9	15	6.5	15.1	T
Duluth	1,133	5	47	28.80	30.07	+.01	20.6	−3.1	40	30	28	−8	22	13	26	18	14	79	1.58	.0	8	12.8	ne.	36	nw.	14	13	5	13	5.4	14.6	.8
North Dakota							21.5	−0.9										83	0.93	+0.1										7.0		
Moorhead, Minn	899	50	58	29.09	30.11	+.03	20.4	−2.3	41	18	26	−10	25	14	30	18	16	86	1.33	+.3	12	7.6	nw.	20	n.	13	5	6	20	7.6	14.6	3.1
Bismarck [2]	1,660	4	41	28.25	30.08	+.02	26.6	+2.4	59	16	35	−1	23	18	32	25	22	82	.79	−.1	13	10.1	e.	37	nw.	19	2	6	23	8.1	9.2	T
Devils Lake	1,478	11	44	28.46	30.11	+.06	16.6	−3.2	40	4	26	−15	23	7	34	16	14	91	.92	+.1	9	7.4	nw.	19	n.	13	6	9	16	6.5	7.1	3.5
Lemmon, S. Dak	1,457	11	71																													
Grand Forks	832	12	67				16.6	−5.8	36	30	27	−15	23	6	38	16	13		.82	+.1	5		nw.								7.4	5.7
Williston	1,878	42	50	28.02	30.07	+.03	27.3	+4.4	58	16	34	5	23	20	36	25	20	74	.77	+.1	12	8.2	se.	25	nw.	19	9	10	12	5.9	5.9	T
Upper Mississippi Valley							34.0	−2.3										74	1.82	−0.6										7.1		
Minneapolis, St. Paul, Minn [1]	838	32	61	29.12	30.06	+.01	24.2	−5.4	51	30	32	−5	25	17	35	21	17	78	2.16	+.7	9	10.1	e.	33	w.	29	7	9	15	6.7	25.6	T
Springfield, Minn	1,025	4	42																													
La Crosse [2]	672	11	48	29.29	30.05	+.01	28.4	−3.1	65	30	35	2	24	21	32	22	19	79	1.85	+.2	9	5.8	nw.	21	sw.	29	5	11	15	6.7	18.3	.0
Madison [2]	866	70	78	29.07	30.04	.00	26.6	−4.0	63	30	32	3	23	21	21	24	20	79	1.09	−1.0	9	8.9	nw.	29	sw.	29	6	9	16	7.1	8.0	T
Charles City	1,015	10	51	28.92	30.05	.00	28.3	−2.4	68	30	36	2	23	21	34	25	21	78	1.50	−.3	8	7.2	ne.	25	sw.	29	6	10	15	6.9	16.8	.0
Davenport	606	66	161	29.35	30.03	.00	33.6	−2.5	74	30	40	10	23	27	30	29	24	70	1.71	−.6	9	10.8	ne.	36	sw.	29	5	9	17	7.1	2.9	.0
Des Moines [2]	863	5	99	28.95	30.01	−.03	33.6	−2.3	75	30	41	9	23	26	32	30	26	80	1.67	−.1	12	10.9	n.	32	sw.	29	4	7	20	7.6	9.5	.0
Dubuque	690	60	79	29.26	30.04	.00	30.6	−3.4	70	30	37	6	23	24	34	27	22	72	.72	−1.3	10	7.2	nw.	21	e.	11	3	8	20	7.5	5.8	T
Keokuk	614	64	78	29.33	30.01	−.02	37.0	−1.9	76	17	44	14	24	30	34	32	27	69	1.55	−.8	9	8.6	n.	30	sw.	29	4	9	18	7.7	T	.0
Cairo	358	87	93	29.61	30.00	−.04	46.6	−.6	80	31	54	22	25	39	27	41	34	66	3.25	−.5	11	9.6	ne.	26	n.	7	4	10	17	7.0	2.6	.0
Peoria [2]	662	11	45	29.28	30.01	−.02	35.9	−1.1	75	17	44	10	25	28	37	30	26	76	2.10	−.6	13	7.8	ne.	24	sw.	29	11	8	12	5.5	2.3	.0
Springfield, Ill. [2]	631	5	191	29.32	30.00	−.03	39.5	−.7	76	17	47	15	25	32	36	33	30	77	2.80	−.4	10	12.0	w.	30	w.	19	2	8	21	8.0	.1	.0
St. Louis [3]	564	179	303	29.38	30.00	−.03	43.6	−.5	87	31	52	18	25	36	33	37	30	62	1.50	−1.9	10	12.1	nw.	27	sw.	28	5	7	19	6.9	1.4	.0
Missouri Valley							38.0	−0.2										76	2.03	+0.1										7.4		
Columbia, Mo. [2]	785	6	66	29.13	29.99	−.04	42.3	−.3	86	31	51	19	24	34	41	36	31	73	1.87	−1.1	11	9.1	e.	21	s.	28	4	10	17	7.1	.5	.0
Kansas City [1]	750	38	76	29.15	29.98	−.04	42.7	.0	86	31	51	20	24	34	40	37	31	67	1.95	−.6	7	12.8	ne.	50	sw.	28	3	11	17	7.4	.6	.0
St. Joseph [2]	817	11	49	29.09	29.98		40.8	+.3	85	31	49	18	24	32	38	36	31	76	2.24	−.2	12	10.3	nw.	35	w.	28	5	7	19	7.4	1.1	.0
Springfield, Mo. [2]	1,360	5	78	28.51	29.97	−.05	43.8	−1.4	83	31	55	15	25	33	45	38	34	74	2.44	−1.0	9	10.3	se.	26	se.	1	7	7	17	6.7	5.5	.0
Topeka	987	65	87	28.90	29.96		43.2	+.6	86	31	53	19	14	34	41	37	31	67	1.38	−.7	7	11.1	ne.	36	s.	28	5	7	19	7.2	.5	.0
Lincoln [2]	1,189	11	81	28.70	29.99	−.03	37.5	.0	78	30	46	14	14	29	41	33	29	77	1.55	+.3	14	10.8	n.	34	nw.	19	4	9	18	7.3	6.1	.0
Omaha [1]	982	31	44	28.94	30.01	−.03	35.6	−1.4	76	30	44	13	14	28	35	32	28	79	1.71	+.3	10	11.9	nw.	33	se.	28	3	6	22	8.0	8.1	.0
Valentine	2,598	47	54	27.22	30.00	−.03	33.8	+1.5	70	30	42	9	13	26	37	30	27	80	1.72	+.7	15	9.5	e.	23	nw.	19	4	6	21	7.9	10.2	.0
Sioux City	1,138	64	106	28.78	30.03	−.02	32.0	−.7	73	30	40	10	23	24	33	29	26	80	3.30	+2.2	12	9.6	e.	37	nw.	29	3	6	22	7.9	14.7	.0
Huron [1]	1,289	26	41	28.64	30.06	.00	27.9	−1.0	55	30	35	−3	23	21	34	26	24	86	2.14	+1.2	15	11.4	nw.	49	nw.	19	5	5	21	7.6	20.1	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, March, 1940*—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch, or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							37.3	+5.4										67	1.13	+0.2										7.2		
Billings	3,570	18	39	26.25	29.99		38.8		64	15	48	15	12	30	29	33	26	64	0.60		7	11.2	sw.	33	nw.	14	2	6	23	8.5	1.1	0.00
Havre	2,507	11	67	27.31	30.00	0.00	32.9	+5.8	63	15	41	9	12	24	35	30	26	76	1.04	+0.5	11	9.6	e.	24	sw.	17	7	13	11	6.0	10.8	.0
Helena	4,124	85	111	25.73	29.96	-.05	39.6	+7.2	61	15	48	20	12	31	31	33	25	57	.65	-.1	5	8.1	sw.	27	sw.	5	2	6	23	8.3	5.2	.0
Missoula [2]	3,189	80	91				42.6	+7.0	68	22	52	21	13	33	38	36	30	68	1.22	+.2	14	6.1	se.	24	sw.	27	3	9	19	7.6	1.1	.0
Kalispell	2,973	48	56	26.88	29.96	-.03	40.2	+7.3	65	21	48	20	13	32	33	35	29	68	1.10	+.2	13	5.3	w.	17	sw.	17	1	8	22	8.0	2.3	.0
Miles City [2]	2,634	48	55	27.19	30.00	-.02	36.0	+7.4	65	16	44	14	13	28	30	31	27	76	1.06	+.2	9	6.7	ne.	28	n.	6	4	9	18	7.7	5.8	.0
Rapid City [2]	3,218	50	58	26.61	30.02	+.01	34.0	+1.4	67	30	42	6	14	26	34	29	26	80	1.03	+.1	16	7.6	n.	27	n.	19	5	7	19	7.5	6.0	.0
Cheyenne [1]	6,144	5	39	23.84	29.92	-.04	38.0	+4.9	70	31	49	12	12	26	39	31	22	58	1.21	+.2	8	14.0	nw.	35	nw.	15	5	10	16	6.7	9.7	.0
Lander	5,352	60	68	24.55	29.91	-.08	38.6	+6.2	67	22	52	4	12	26	39	32	23	56	1.02	-.2	6	6.0	sw.	32	sw.	31	5	13	13	6.2	9.7	.0
Sheridan	3,790	10	47	26.02	29.96		38.7		67	30	50	15	12	27	35	33	27	66	.93	-.2	8	5.7	nw.	21	nw.	18	3	9	19	7.5	.8	.0
Yellowstone Park	6,241	12	46	23.81	30.06	+.04	32.0	+4.8	58	22	42	0	12	22	32	28	22	66	2.00	+1.0	16	8.0	sw.	30	sw.	15	7	7	17	6.7	15.8	.0
North Platte [2]	2,787	11	51	27.02	29.96	-.04	39.0	+2.4	82	31	51	5	14	27	42	33	28	73	1.12	+.3	6	8.7	n.	27	n.	9	11	7	13	5.6	3.4	.0
Middle Slope							45.5	+2.2										62	1.04	-0.2										5.2		
Denver [2]	5,332	106	113	24.60	29.91	-.04	42.8	+3.5	76	31	54	14	13	32	39	33	25	59	2.29	+1.2	9	8.0	s.	22	ne.	23	10	10	11	5.5	20.0	.0
Pueblo [2]	4,806	79	86	25.07	29.88	-.04	44.8	+3.2	79	31	59	15	13	31	50	35	25	55	.36	-.2	5	7.4	nw.	26	w.	27	13	12	6	4.5	3.5	.0
Chadron, Nebr	3,439	4	58																													
Concordia	1,392	50	58	28.47	29.97	-.04	41.4	+.4	82	31	52	15	14	31	42	36	31	71	1.55	+.3	6	9.9	n.	28	sw.	28	7	8	16	6.7	2.9	.0
Dodge City	2,509	10	86	27.29	29.92	-.05	45.6	+2.8	88	31	59	18	13	32	45	37	29	61	1.31	+.4	6	13.1	ne.	39	ne.	1	11	13	7	4.8	.8	.0
Wichita [2]	1,392	85	93	28.45	29.93	-.06	46.2	+1.1	88	31	57	20	14	35	40	38	31	66	.74	-1.0	9	12.0	se.	34	ne.	1	10	13	8	4.9	.1	.0
Oklahoma City [2]	1,304	10	47	28.54	29.92	-.06	52.2	+2.2	94	31	65	22	13	39	37	42	33	58	.02	-2.0	1	11.4	s.	33	nw.	18	10	14	7	4.8	.0	.0
Southern Slope							56.6	+2.1										48	0.68	-0.2										4.4		
Abilene [2]	1,750	10	56	28.09	29.90	-.06	59.6	+3.1	95	31	74	28	13	46	39	46	33	45	.27	-1.0	3	11.9	s.	34	sw.	1	16	10	5	4.2	.0	.0
Amarillo [2]	3,604	10	49	26.23	29.89	-.06	50.7	+3.8	87	31	66	21	24	36	40	38	27	53	.24	-.5	2	10.3	sw.	32	w.	6	15	12	4	3.7	.2	.0
Del Rio	960	63	71	28.91	29.90	-.05	63.7	+.2	90	31	75	35	14	53	34	53	43	55	2.21	+1.5	5	9.6	se.	34	n.	6	10	11	10	5.4	.0	.0
Roswell	3,566	75	85	26.29	29.89	-.01	52.6	+1.3	86	31	69	19	14	36	48	41	25	40	T	-.7	0	9.5	s.	37	nw.	1	14	11	6	4.2	.0	.0
Southern Plateau							53.7	+3.6										40	0.40	-0.4										3.8		
El Paso [2]	3,916	82	101	25.97	29.86	-.02	58.4	+2.6	85	31	71	26	14	45	42	42	22	31	.02	-.3	1	8.9	w.	25	sw.	27	18	12	1	3.1	.0	.0
Albuquerque [1]	5,314	5	34	24.67	29.86		49.0	+3.1	77	31	64	22	13	34	38	37	23	42	.48	.0	4	9.6	w.	38	nw.	1	14	9	8	4.5	T	.0
Santa Fe	7,013	38	53	23.15	29.90	+.01	42.2	+2.5	67	31	54	15	13	30	32	32	18	43	1.52	+.7	6	6.6	n.	25	w.	11	17	6	8	4.1	14.6	.0
Flagstaff	6,907	10	59	23.28	29.86	-.05	39.8	+3.9	69	24	55	12	14	25	43	32	23	57	.27	-2.3	5	9.2	nw.	29	sw.	11	15	9	7	4.2		
Phoenix [2]	1,102	39	87	28.73	29.88	-.03	64.8	+4.1	88	25	79	39	12	50	41	48	30	34	T	-.7	0	6.0	e.	21	w.	11	16	5	10	4.3	.0	.0
Yuma	142	9	54	29.76	29.91	-.03	67.8	+3.7	92	24	83	42	12	53	42	52	35	35	.21	-.1	2	6.4	sw.	25	se.	22	22	6	3	2.6	.0	.0
Independence	3,957	5	26	25.94	29.98	+.04	54.0	+5.5	81	22	60	25	12	39	40	39	18		.27	.0	2		w.	27	n.	2						
Middle Plateau							44.7	+3.8										53	0.94	-0.2										5.4		
Ely	5,077	5	36		30.01		38.3		69	22	53	14	13	24				56	.51		4	11.0	s.	39	nw.	27	6	14	11		1.7	.0
Reno [2]	4,400	61	76	25.58	30.02	+.04	44.9	+3.8	75	22	57	19	12	33	42	36	27	57	.82	.0	6	7.2	w.	30	w.	9	10	12	9	5.0	.7	.0
Tonopah	6,090	12	20				44.8		68	22	55	18	11	34	28	37	28		.34		3		nw.				12	14	5		T	T
Winnemucca	4,344	18	56	25.60	30.02	+.01	42.9	+2.9	75	22	58	14	12	28	52	35	25	57	1.41	+.4	9	7.5	sw.	29	sw.	26	10	7	14	5.9	2.4	.0
Modena	5,473	10	46	24.57	29.92	-.04	41.7	+3.5	75	23	58	12	13	26	49	32	18	46	.07	-1.0	3	10.4	w.	34	s.	31	9	10	12	5.7	T	.0
Salt Lake City [1]	4,227	86	210	25.70	29.98	.00	46.6	+4.9	75	24	57	22	12	36	32	38	29	57	1.52	-.5	9	7.4	nw.	37	nw.	27	12	8	11	5.5	4.1	.0
Grand Junction	4,602	60	68	25.31	29.88	-.06	47.3	+3.7	75	25	60	19	13	34	35	37	24	43	.88	+.1	4	6.6	se.	31	w.	11	10	13	8	5.1	2.1	.0
Northern Plateau							45.8	+4.5										61	1.92	+0.8										7.0		
Baker	3,373	36	54	26.52	30.03	.00	41.8	+4.2	70	22	52	21	11	31	42	36	30	71	1.92	+.8	14	6.5	s.	20	n.	2	7	12	12	6.3	1.0	.0
Boise [2]	2,858	5	49	27.03	30.01	-.02	45.6	+2.9	70	22	56	24	12	35	35	39	31	61	2.26	+.9	11	10.7	se.	34	nw.	2	8	7	16	6.4	T	.0
Pocatello [1]	4,478	5	31	25.43	29.98	-.03	41.3	+3.9	69	22	52	17	6	30	40	35	27	58	.79		9	10.1	sw.	34	w.	8	3	11	17	7.1	1.4	.0
Spokane [2]	1,968	101	110	27.89	29.98	-.03	45.3	+5.6	67	23	54	26	11	36	33	40	33	68	2.91	+1.7	12	6.1	s.	18	s.	29	2	12	17	6.9	T	.0
Walla Walla	991	57	65	28.92	30.00	-.02	51.6	+5.5	74	23	60	34	13	43	28	44	35	56	2.20	+.6	13	5.8	s.	19	sw.	4	4	6	21	7.8	.0	.0
Yakima	1,076	58	67	28.82	29.98		49.2	+5.1	75	22	60	28	9	38	36	42	32	54	.31	-.1	3	5.5	nw.	25	nw.	16	4	9	18	7.4	.0	.0
North Pacific Coast Region							50.0	+4.6										76	5.71	+1.6										7.5		
North Head	211	5	56	29.79	30.02	+.01	48.8	+3.6	63	21	53	37	10	44	19	46	44	85	8.73	+3.2	23	15.4	s.	61	s.	1	3	4	24	8.1	.0	.0
Seattle [2]	14	90	321	29.96	30.00	+.01	50.7	+5.8	68	23	57	38	21	44	28	45	41	74	4.39	+1.3	17	8.9	s.	45	s.	29	4	10	17	7.2	.0	.0
Tacoma	194	172	201	29.79	30.00	.00	49.2	+5.0	65	23	56	34	21	42	26				4.44	+1.0	18	8.2	s.	36	s.	29	4	5	22	7.8	.0	.0
Tatoosh Island	86	9	61	29.88	29.98	+.02	47.7	+4.8	56	21	51	39	10	44	12	45	42	82	8.68	+.8	22	13.3	e.	43	s.	1	7	2	22	7.5	.0	.0
Medford [1]	1,329	29	58	28.62	30.04		50.0	+3.1	81	21	62	26	12	38	45	44	38	68	4.19	+2.5	13		nw.				6	7	18	6.7	T	.0
Portland, Oreg. [2]	39	68	106	29.97	30.02	.00	51.8	+4.9	72	23	59	39	10	44	28	47	43	75	5.12	+1.2	18	6.0	se.	27	s.	29	4	3	24	8.0	.0	.0
Roseburg	510	45	76	29.48	30.04	.00	51.8	+4.7	79	21	62	32	10	41	41	46	41	70	4.40	+1.1	18	4.1	nw.	30	sw.	29	3	10	18	7.5	.0	.0
Middle Pacific Coast Region							55.5	+2.8										70	6.70	+2.8										5.9		
Eureka	60	72	88	30.01	30.08	+.02	51.4	+3.1	67	18	58	35	10	45	24	48	44	79	7.70	+2.5	17	7.8	se.	31	sw.	26	7	6	18	6.9	T	.0
Redding [1]	722	20	34	29.24	30.01		56.4	+2.4	86	20	65	34	11	48	33	47	36	53	9.57	+4.9	9	8.4	nw.	31	s.	26	10	6	15	6.0	.0	.0
Sacramento [2]	25	92	115	30.00	30.02	-.01	56.7	+2.4	77	19	66	37	12	48	28	51	46	71	4.22	+1.6	7	7.5	se.	24	n.	3	12	8	11	4.9	.0	.0
San Francisco	155	112	132	29.86	30.03	-.03	57.4	+3.2	72	6	63	47	12	52	20	52	48	76	5.32	+2.2	9	7.7	w.	26	w.	9	9	11	11	5.7	.0	.0
South Pacific Coast Region							59.7	+3.3										65	1.10	-0.9										5.5		
Fresno [1]	327	89	98	29.72	30.04	+.03	57.6	+2.6	80	21	70	34	12	45	35	51	45	67	.92	-.7	8	6.0	nw.	21	nw.	2	10	8	13	5.8	.0	.0
Los Angeles	512	223	250	29.47	30.01	-.01	61.2	+3.7	82	6	70	45	11	52	29	52	44	61	1.55	-1.2	4	6.2	w.	26	sw.	11	12	6	13	5.1	.0	.0
San Diego [2]	28	62	70	29.96	29.99	-.03	60.3	+3.6	81	14	69	43	12	52	37	53	48	68	.82	-.9	4	6.7	w.	28	se.	31	12	3	16	5.7	.0	.0
West Indies																																
San Juan, P. R	82	10	54	29.90	29.99		76.4	+1.0	90	7	81	66	4	72	17				2.16	-1.0	11	11.9	e.	27	e.	28	9	20	2	4.6	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, March, 1940*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air													Precipitation			Wind									
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch, or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Panama Canal	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0-10*	*In.*	*In.*
Balboa Heights	118	6	92	------	[3]29.82	−0.03	82.4	+1.2	94	29	91	68	8	74	22	12	5	[3]72	0.75	0.0	4	8.3	nw.	27	n.	17	4	27	0	4.8	0.0	0.0
Cristobal	36	6	97	------	[3]29.84	−.03	82.2	+.7	88	25	86	72	8	78	12	75	73	[3]77	.63	−.9	9	12.6	n.	25	n.	9	5	19	7	5.6	.0	.0
Alaska																																
Fairbanks	454	11	87	[4]29.31	[4]29.86	------	12.6	+2.6	53	27	26	−26	19	0	47	12	5	64	.03	−.7	3	5.0	n.	24	ne.	24	8	8	15	6.1	1.3	7.3
Juneau	80	96	116	[4]29.71	[4]29.80	------	35.6	+1.9	53	27	41	17	23	30	22	33	28	72	5.18	−.5	22	7.0	se.	24	ne.	23	3	3	25	8.7	32.2	.0
Nome	22	5	59	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Hawaiian Islands																																
Honolulu	38	86	100	29.90	29.94	------	72.8	+1.4	83	25	78	62	20	67	17	66	63	73	1.76	−1.4	5	7.3	ne.	21	sw.	16	10	11	10	5.1	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to a mean of 24 hours.
[5] Barometric data from city office records.

NOTE.—Except as indicated by notes 1 and 2, data in table 2 are city office records.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, March, 1940*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea-level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Cape Race, New Foundland	99				32.1	+4.4	36.2	28.0	43	20	5.68	+1.78	8.5
North Sydney, Cape Breton Island	8	29.75	29.76	−0.15	29.8	+2.6	35.6	24.1	48	0	6.25	+1.66	8.8
Halifax, Nova Scotia	88	29.53	29.80	−.12	29.8	−.6	35.1	24.4	48	7	6.64	+1.81	11.2
Yarmouth, Nova Scotia	65	29.72	29.83	−.11	30.4	−1.6	36.4	24.5	49	7	3.31	−.80	6.9
Charlottetown, Prince Edward Island	38	29.71	29.80	−.11	27.6	+1.8	33.6	21.7	47	3	3.01	−.65	15.4
Chatham, New Brunswick	28	29.68	29.79	−.13	25.0	+.5	33.5	16.6	51	−14	4.19	−.84	27.2
Father Point, Quebec	20	29.81	29.83	−.09	23.4	+1.8	29.0	17.7	43	−9	1.93	−.99	19.2
Quebec, Quebec	296	29.53	29.86	−.10	23.6	+1.3	30.0	17.3	50	−2	3.37	+.17	29.8
Senneterre, Quebec [3]	1,038	------	------	------	------	------	------	------	------	------	------	------	------
Montreal, Quebec (St. Hubert Airport)[2]	102	29.79	29.91	−.07	21.2	−3.3	28.7	13.8	43	−17	3.15	−.30	27.2
Ottawa, Ontario	236	29.53	29.91	−.09	18.8	−5.3	27.2	10.5	44	−9	2.86	+.21	28.1
Kingston, Ontario	285	29.63	29.95	−.06	23.0	−4.2	29.8	16.2	46	−3	3.25	+.78	17.2
Toronto, Ontario	379	29.54	29.97	−.06	26.3	−2.5	31.9	20.7	49	5	2.24	−.29	13.8
Porguis Junction	930	[1]28.84	[1]29.99	------	11.7	------	22.1	1.3	39	−20	1.46	------	14.3
White River, Ontario	1,244	28.65	30.06	+.02	9.6	−3.7	25.9	−6.8	41	−39	1.02	−.48	7.3
London, Ontario	808	29.07	29.98	------	23.7	−6.1	29.7	17.7	53	−5	2.63	−.29	17.5
Southampton, Ontario	656	29.23	29.96	−.03	22.6	−4.6	28.3	17.0	50	−1	2.97	+.29	29.7
Parry Sound, Ontario	688	29.25	29.98	−.04	21.0	−2.8	29.2	12.9	47	−9	1.89	−.84	18.7
Port Arthur, Ontario	644	29.34	30.08	+.03	15.6	−4.7	26.4	4.9	38	−15	1.82	+.88	11.6
Winnipeg, Manitoba	760	29.23	30.14	.00	17.0	+1.2	26.6	7.5	35	−13	.65	−.48	6.5
Minnedosa, Manitoba	1,690	28.24	30.14	+.06	16.2	+1.2	26.0	6.5	39	−21	.43	−.40	4.3
Le Pas, Manitoba	860	29.14	30.16	+.04	14.9	+3.9	26.6	3.2	46	−26	.84	+.27	8.4
Qu'Appelle, Saskatchewan	2,115	27.74	30.11	+.03	18.9	+1.6	27.8	10.0	45	−14	1.55	+.38	14.7
Regina, Saskatchewan	1,900	[1]28.02	[1]30.13	------	17.8	+1.3	26.0	9.5	40	−8	.54	−.13	4.3
Swift Current, Saskatchewan	2,392	27.16	30.08	+.03	23.1	+1.5	29.7	16.5	45	1	.51	−.24	5.0
Medicine Hat, Alberta	2,365	27.45	30.02	.00	27.4	−.5	34.8	20.0	47	2	1.61	+1.02	14.7
Calgary, Alberta	3,540	26.24	30.02	.00	26.9	+1.8	34.4	19.4	55	1	.82	−.02	7.6
Prince Albert, Saskatchewan	1,450	28.51	30.13	+.06	18.0	+4.0	27.4	8.6	46	−16	.35	−.55	3.5
Battleford, Saskatchewan	1,592	28.27	30.08	+.03	17.4	+2.3	26.4	8.5	41	−9	.22	−.31	2.2
Edmonton, Alberta	2,150	27.60	30.03	------	23.2	+.9	30.5	15.9	45	−7	2.76	+2.02	27.6
Kamloops, British Columbia	1,262	28.59	29.95	+.02	44.2	+6.3	54.3	34.1	69	24	.76	+.40	.2
Victoria, British Columbia	230	29.73	29.98	−.05	48.0	+4.4	53.6	42.5	60	37	2.96	+.58	.0
Barkerville, British Columbia	4,180	------	------	------	------	------	------	------	------	------	------	------	------
Estevan Point, British Columbia	20	29.94	29.97	−.05	45.4	+2.6	51.1	39.6	55	32	16.26	+7.05	.0
Prince Rupert, British Columbia	170	29.67	29.86	.00	42.6	+3.6	48.3	36.8	59	30	8.16	−.96	.0
St. George's, Bermuda	158	------	------	------	------	------	------	------	------	------	------	------	------
LATE REPORTS FOR FEBRUARY 1940													
Cape Race, Newfoundland	99			------	25.4	+3.2	31.3	19.4	41	5	6.24	+2.29	19.7
Quebec, Quebec	296	29.63	29.97	−0.04	15.4	+3.9	22.6	8.1	33	−6	2.08	−1.05	20.8
St. George's, Bermuda	158	------	29.95	−.16	59.3	−2.5	64.1	54.4	70	44	4.84	+.05	.0

[1] Pressure not reduced to a mean of 24 hours.
[2] Observations taken at St. Hubert Airport of Montreal.
[3] Station at Doucet, Quebec, closed Senneterre, substituted.

TABLE 4.—*Severe local storms, March 1940*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

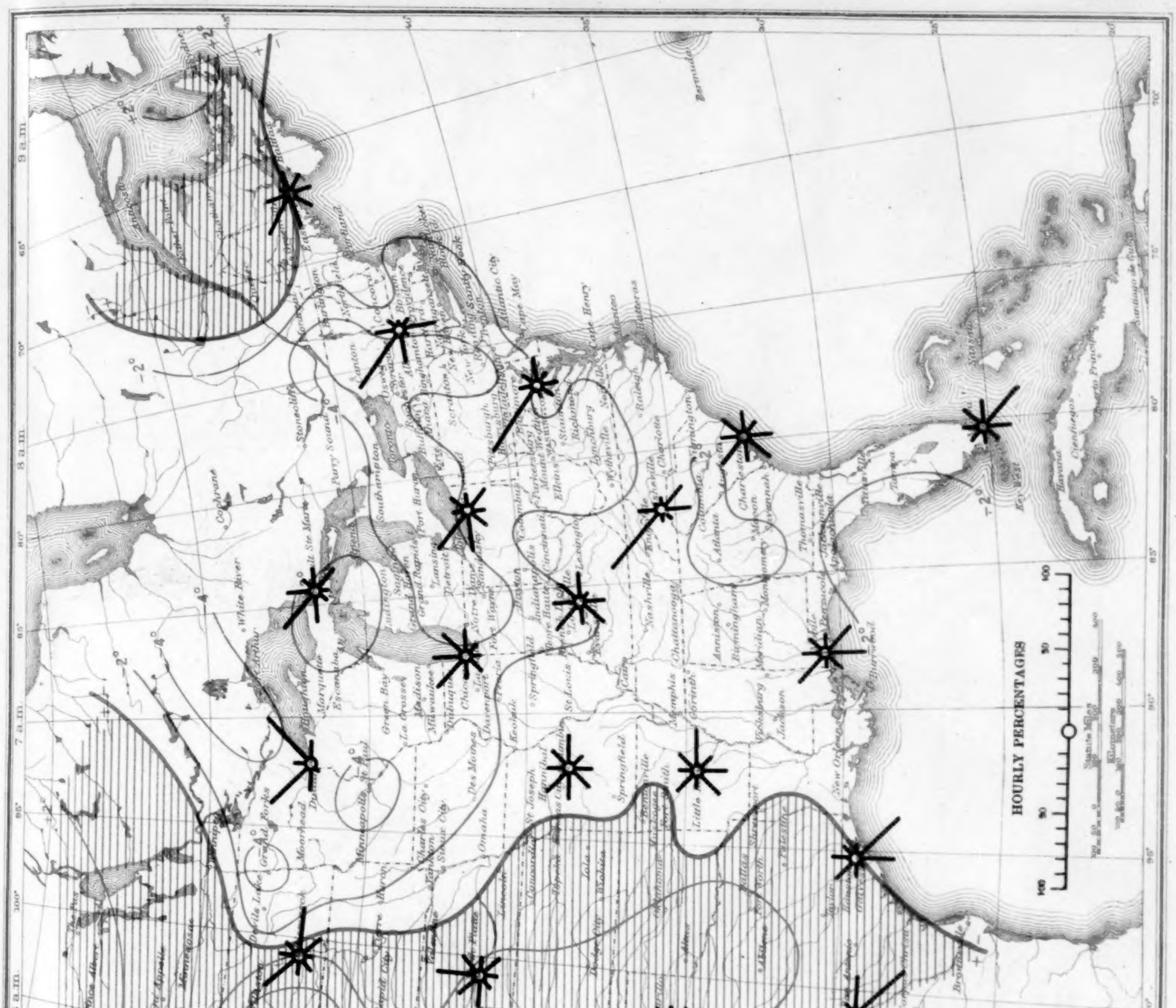
The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Fort Morgan to Lemar, Colo.	1				$600,000	Wind, snow and dust.	Much damage to utilities. All travel disrupted in southeastern cities and towns due to thick dust. Many residences and business houses damaged.
Shawneetown, Ill.	2	12:30 p. m.	100	0	10,000	Tornado	School building unroofed; path 3 miles long.
Evansville, Ind.	2	1:40 p. m.	30–150	1	150,000	do	Path west-southwest to east-northeast; 19 persons injured, 2 seriously; 275 homes and other buildings damaged or destroyed; damage to automobiles standing in the path; trees uprooted
Boonville, Ind., 5 miles northwest.	2	2:15 p. m.	50	0	10,000	do	Direction of path southwest to northeast; 5 persons injured.
Dubois County, Ind.	2	do	[1] 1	0	4,500	Hail	Roofs, windows and greenhouses damaged.
Alton, Ill.	2	3:30 p. m.	35	0	200,000	Tornado and hail	Heavy hail preceded and followed the period of tornadic winds. Wind damage amounted to $150,000, including the unroofing of 12 residences and damage to approximately 750 other buildings; hail damage, $5,000.
Bunker Hill, Ill., 4 miles southeast.	2	do	150	0		Tornado	Length of path 4 miles; no details.
Carlinville, Ill.	2				1,000	Hail	Property damaged.
Glendale, Ill.	2				500	do	Do.
Huron, Bakerville, McEwen and Stayton, Tenn., and vicinities.	2	5-6 p. m.		0	28,000	Tornado	More than 15 persons injured; property damaged; path 85 miles long.
Tennessee, northwestern counties.	2				110,000	Wind and hail	Damage from hail, 100,000 in Weakley, Henry, Stewart, and Carroll Counties, Weakley County, alone, reporting $75,000 loss.
Vienna to Glendale Ill.	2		150	1	75,000	Tornado	12 residences, barns, and outbuildings demolished; man killed by flying fence post and 8 others injured.
Espanola, N. Mex.	3	5:30-11 p. m.			15,000	Snow	Damage to utilities, $5,000; loss to fruit crop, $10,000.
Thrasher, Miss.	3	6:30 p. m.	750	0	10,000	Tornado	Property damaged; 6 persons injured; path 3 miles long.
Lower Hudson Valley, N. Y.	4				600,000	Glaze	Thousands of trees ruined or badly damaged; about 50,000 broken or damaged in the Bronx area with estimated loss of from $600,000 to $700,000. Much damage to telephone and power lines. Amount of total storm damage not available, but probably $1,500,000,000 to $2,000,000,000 would be a conservative estimate. The storm was reported to be more devastating to trees and wire lines than the hurricane of September 1938.
Denver, Colo., and vicinity	5-6	P. m.				Wind and snow	Damage to telephone lines.
Artesia, Calif., vicinity of	10			0		Tornado	A whirlwind with a slightly developed funnel cloud not reaching the ground and with no damage reported.
South Dakota	10-12					Wind and snow	Heaviest snow of season, 5 to 12 inches in depth, covered the entire State diagonally from northwest to southeast. In the worst affected places business was suspended entirely, traffic delayed, and schools closed.
Bonham, Tex.	11	4 p. m.	[1] 1			Heavy hail	Property damaged; 1 person injured.
Mount Pleasant, Tex.	11	P. m.			20,000	do	Property damaged.
Shreveport, La.	12	4:30 p. m.	400-2,560	10	2,000,000	Tornadic wind	Several hundred houses demolished or badly damaged; more than 50 persons injured.
Eupora, Miss., vicinity of	12					Severe thundersquall.	Property damaged.
Kilgore, Tex.	12				30,000	Heavy hail	Do.
Washom, Tex.	12			0	25,000	Tornado	Several buildings destroyed, some others unroofed.
Michigan, southern portion	13			2		Sleet	Property damaged.
Demopolis, Ala., vicinity of	13-14				10,550	Heavy rain and flood.	Heavy rains caused minor flooding on the Black Warrior and Tombigbee Rivers with damage mainly below Demopolis.
New York State, central and northern portions.	15					Heavy snow	Highways blocked; much damage to trees, telephone and power lines.
Fredericksburg, Tex.	20	2-3 p. m.	[1] 1		500	Heavy hail	Crop loss, $500.
Llano, Tex.	20	3:30-3:45 p. m.			15,000	do	No property damage; path up to 1½ miles wide.
Bloomingdale, Fla.	21		[1] 1			do	Hail covered the ground to a depth of from 2 to 3 inches. No damage reported as the storm occurred over a wooded and unpopulated area.
New York State, western, central and northern portions.	22-27			7		Snow	During this severe storm, snow drifted badly. Hundreds of automobiles stalled on highways; some branch railroads and many country roads blocked for several days; many rural schools closed. Blizzard conditions existed on the 26th in northern New York. Here thousands of persons were marooned and populous districts threatened with a milk and food shortage. Snow, whipped about by a wind of 50 miles an hour, piled up in depths of from 5 inches to drifts of 30 feet high. Wyoming County isolated, snow plows having difficulty clearing roads leading into it. No busses operated; trains hours behind schedule and airplanes unable to land because of drifted runways at airports. This reported to be the worst storm in 52 years.
Mercedes, Tex.	24	2:30-4:30 p. m.			220,000	Heavy hail	Loss in fruit and vegetable crops about $200,000; other damage, $20,000.
Hope, N. Mex.	26	1-3 p. m.	[1] 2		2,000	Wind and hail	Large barn destroyed.
Minnesota, west-central counties.	27-28				75,000	Snow, sleet, glaze, and wind.	Wires, poles, and trees damaged considerably; traffic delayed.
Rapid City, S. Dak., vicinity of.	27-28					Freezing rain	Rain accompanied by freezing temperature caused much damage to poles and wires, some wires coated to the extent of 4 inches in diameter.
Crawford and Carroll Counties, Iowa.	28			0	25,000	Tornado	Storm apparently traveled across the line of the two counties in a general direction from southeast to northwest. Clubhouse and other buildings destroyed; property damaged.
Grimes, Iowa, vicinity of	28		440	0		do	Farmhouse damaged and all other buildings on the porperty demolished; trees blown down or twisted off; wires down; child slightly injured; path from south to north and a mile long.
Pierre Part, La.	29	10:56 a. m.	400	5	45,000	do	About 60 persons injured and 26 homes destroyed.
Hillsboro, Tex., 3 miles north	29	Noon		0		do	Car lifted from the highway and considerably damaged.
Bryan and Tabor, Tex.	29	1:10-1:30 p. m.			27,000	Wind	Property damaged; 3 persons injured; path up to 20 miles long.
Amite, La., 1 mile south	29	1:15 p. m.	150	1	1,772	Tornado	Several barns and tenant houses demolished.
Plaquemine, La.	29	2 p. m.	100	0	2,500	do	Steel tower blown down; 2 houses demolished and several damaged.
New Iberia, La.	29	2:05 p. m.				Wind	6 small houses blown off foundations; several trees uprooted.
Bogalusa, La., vicinity of	29	2:30 p. m.	200	1	11,000	Tornado	2 persons seriously injured; house demolished and several badly damaged; trees uprooted.
Grapeland, Tex.	29	2:45 p. m.	100	0		do	Buildings damaged; several tenant houses and barns destroyed.
Trinity, Tex.	29	3:30 p. m.	[1] 1			Wind	Several trees blown over; house unroofed.
Popularville, Miss., vicinity of.	29	4:10 p. m.	58	0	5,000	Tornado	Property damaged; 6 persons injured, 3 seriously; path 12 miles long.
Gilbertown, Ala.	29	6 p. m.	440	0	20,000	do	Property damaged; 30 persons injured.
Bucatunna, Miss.	29	do	200	0	7,000	do	Property damaged; 1 person seriously injured; path 1 mile long.
Clarksdale, Miss.	30					Severe thundersquall.	Property damaged.
Lancaster, N. Y.	30				10,000	Flood	Snow, melting rapidly, caused damage by flooding.

[1] Miles instead of yards.

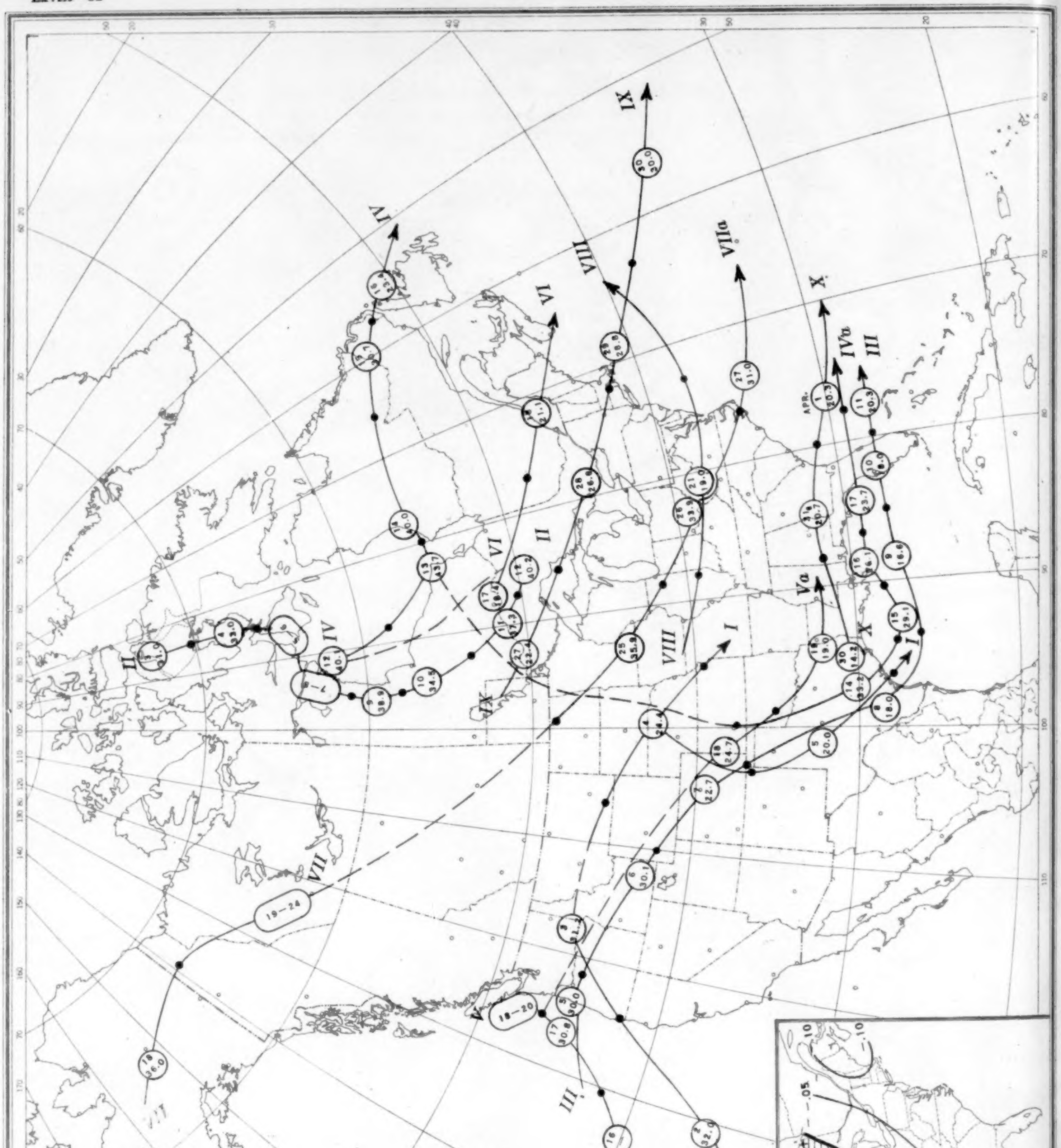
U. S. GOVERNMENT PRINTING OFFICE: 1940

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, March 1940



Shaded portions show excess (+)
Unshaded portions show deficiency (−)
Lines show amount of excess or deficiency

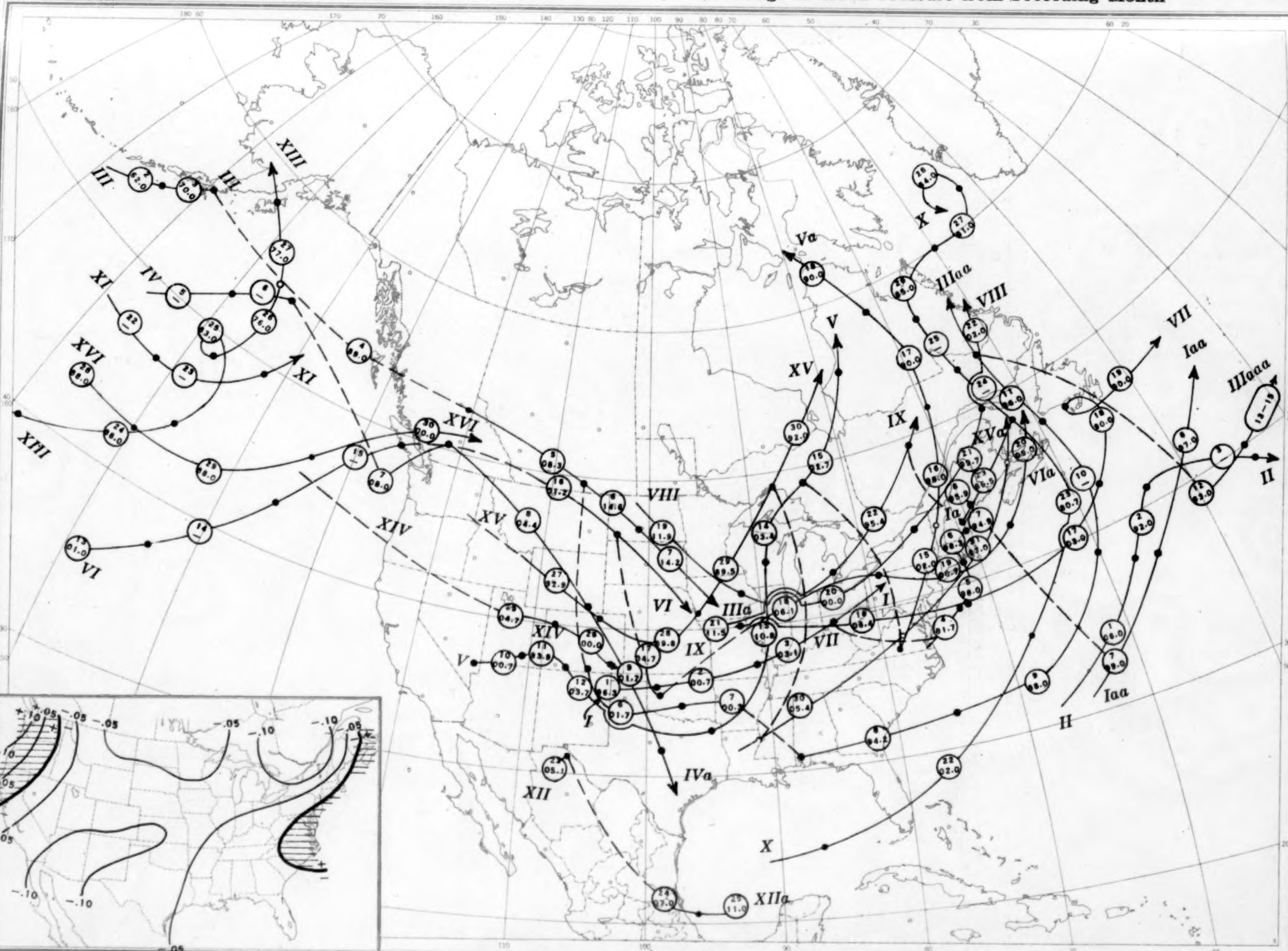
Chart II. Tracks of Centers of Anticyclones, March 1940. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, March 1940. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, March 1940. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, March 1940

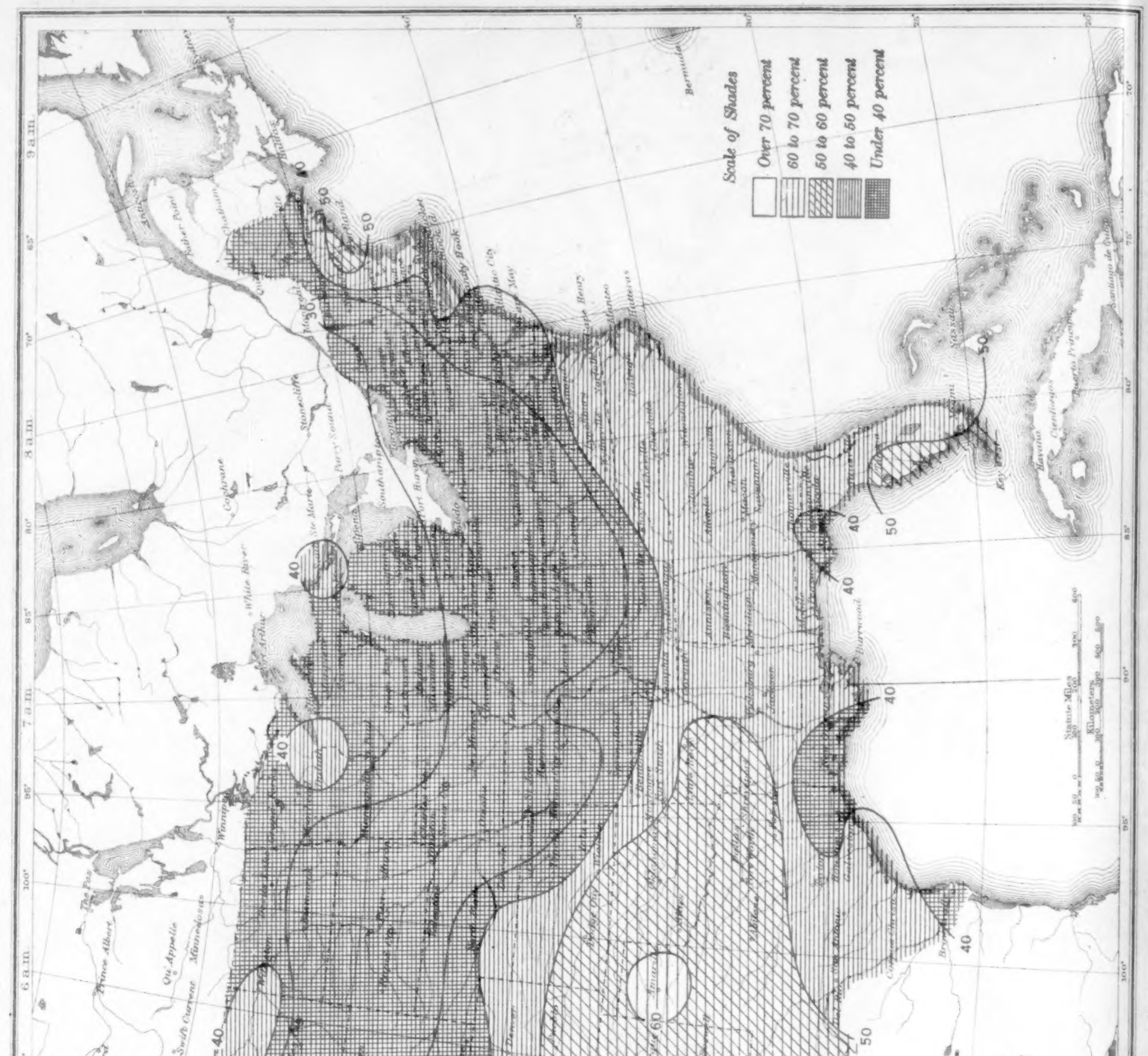
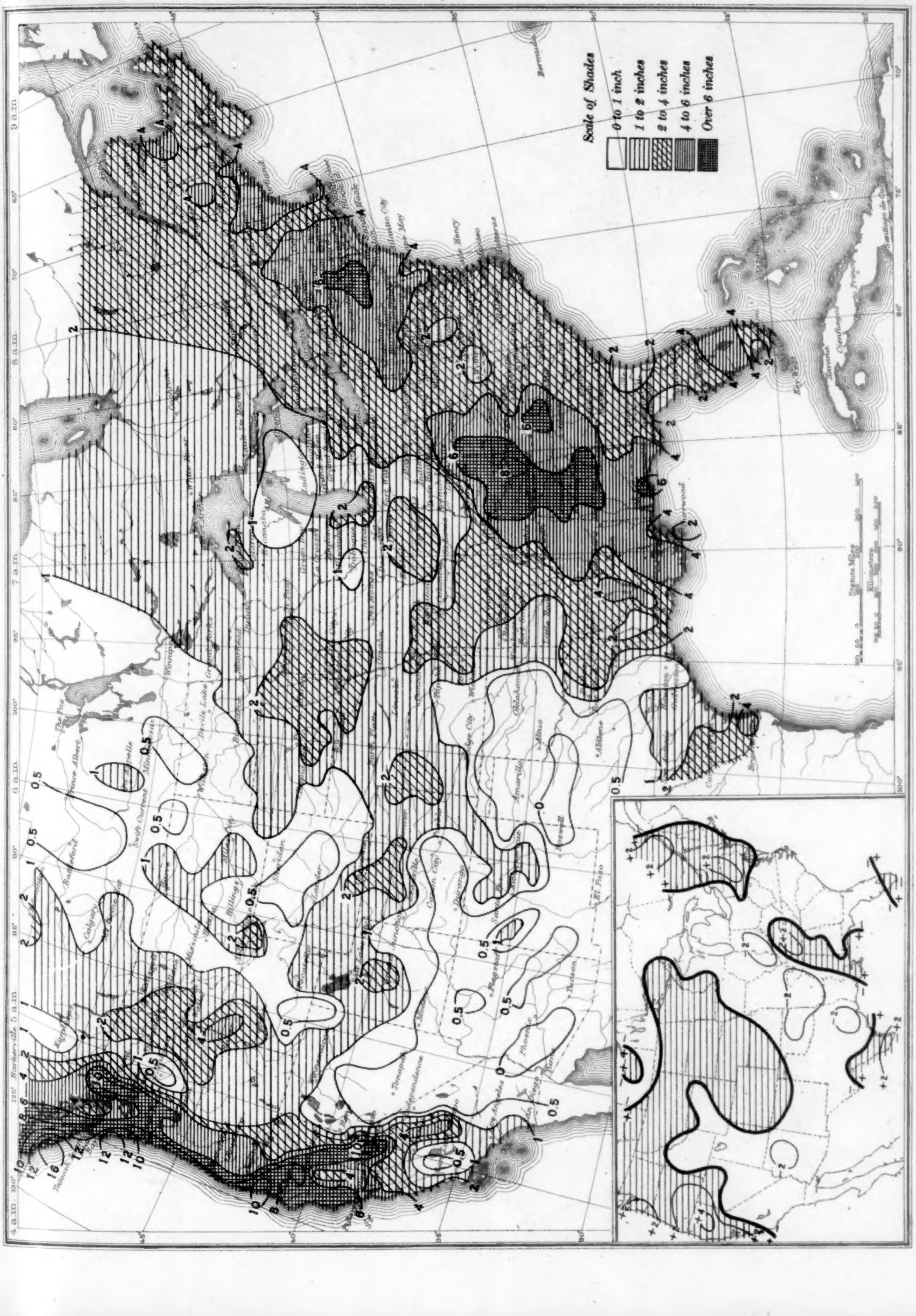


Chart V. Total Precipitation, Inches, March 1940. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, March 1940. (Inset) Departure of Precipitation from Normal



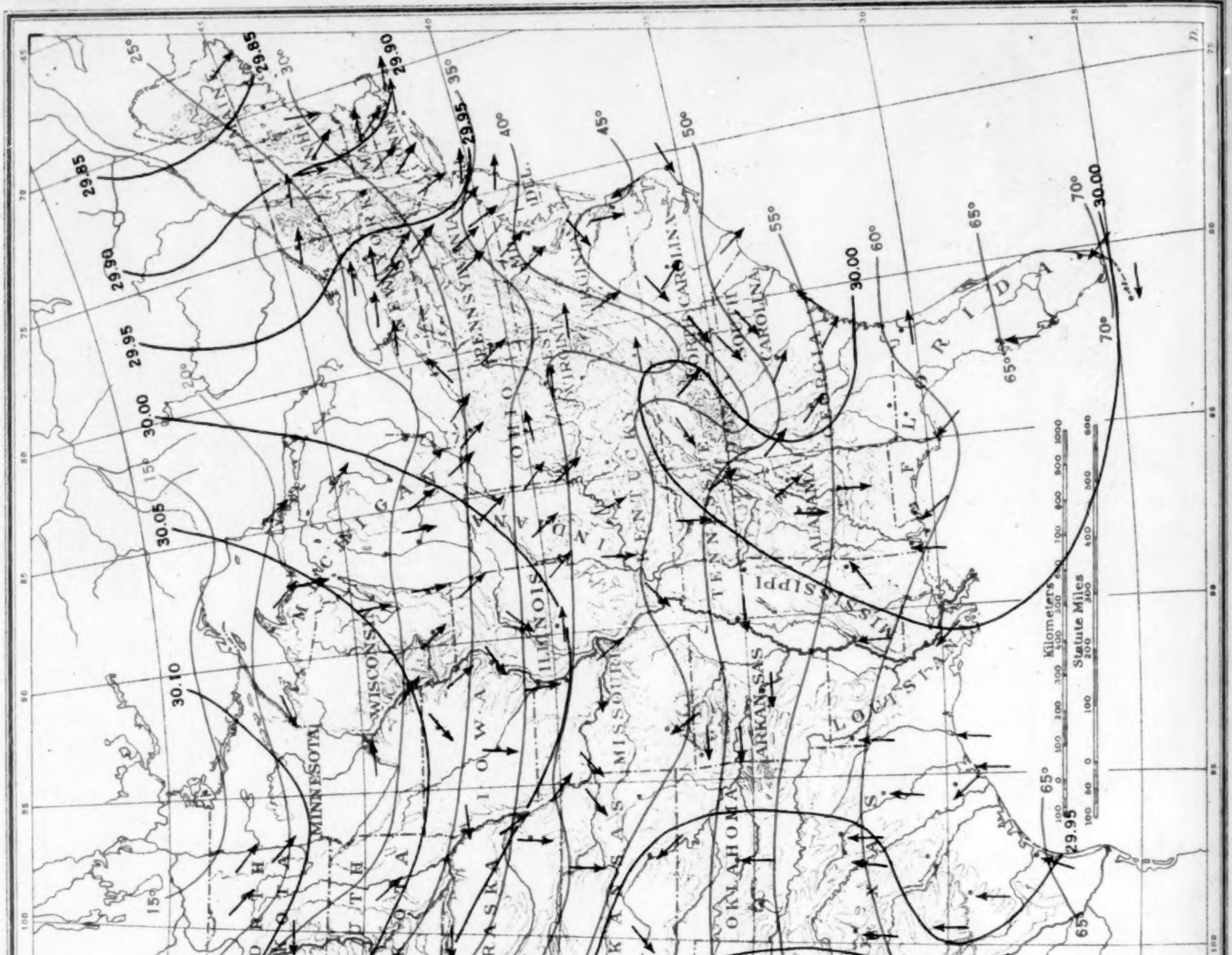


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, March 1940

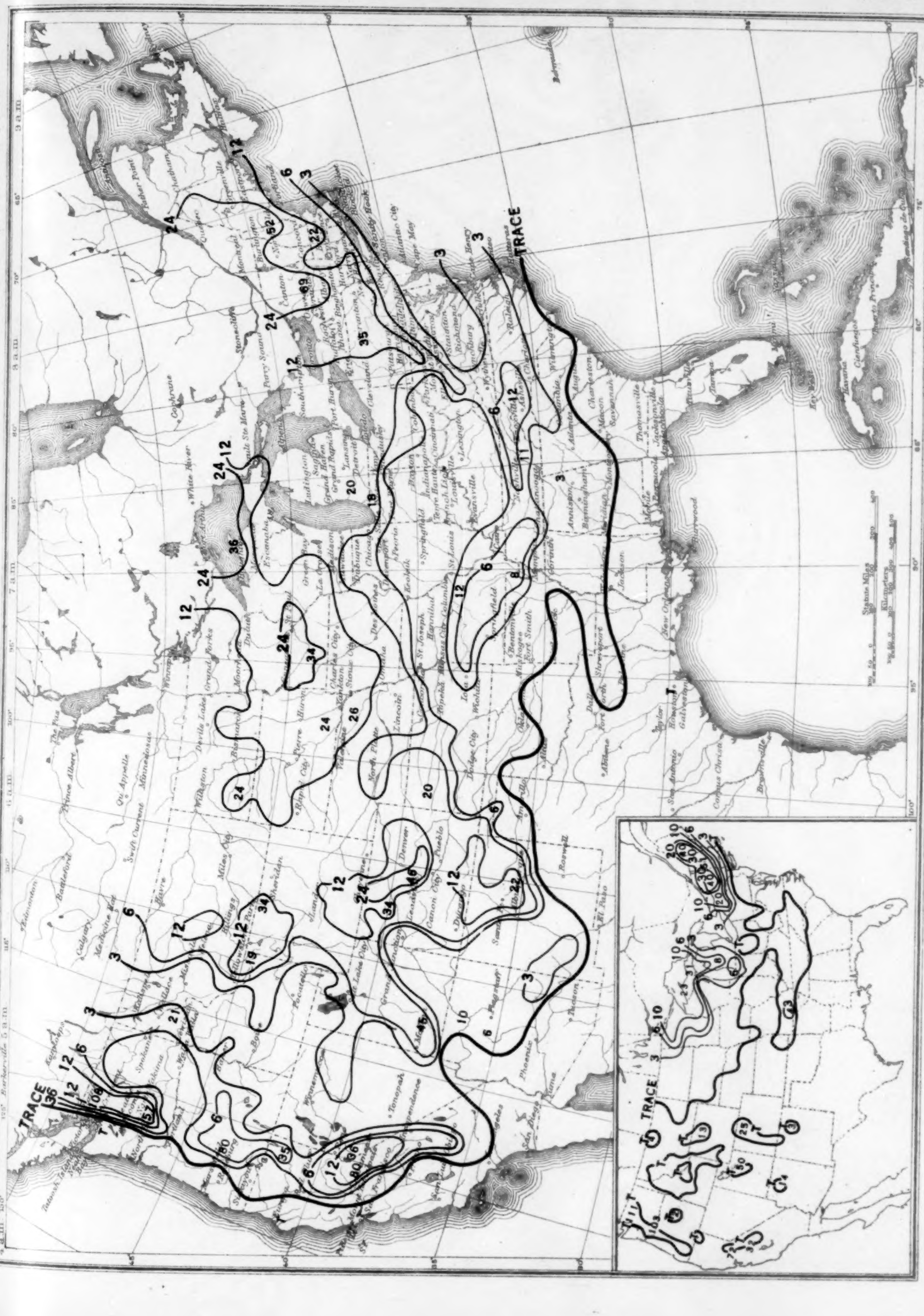
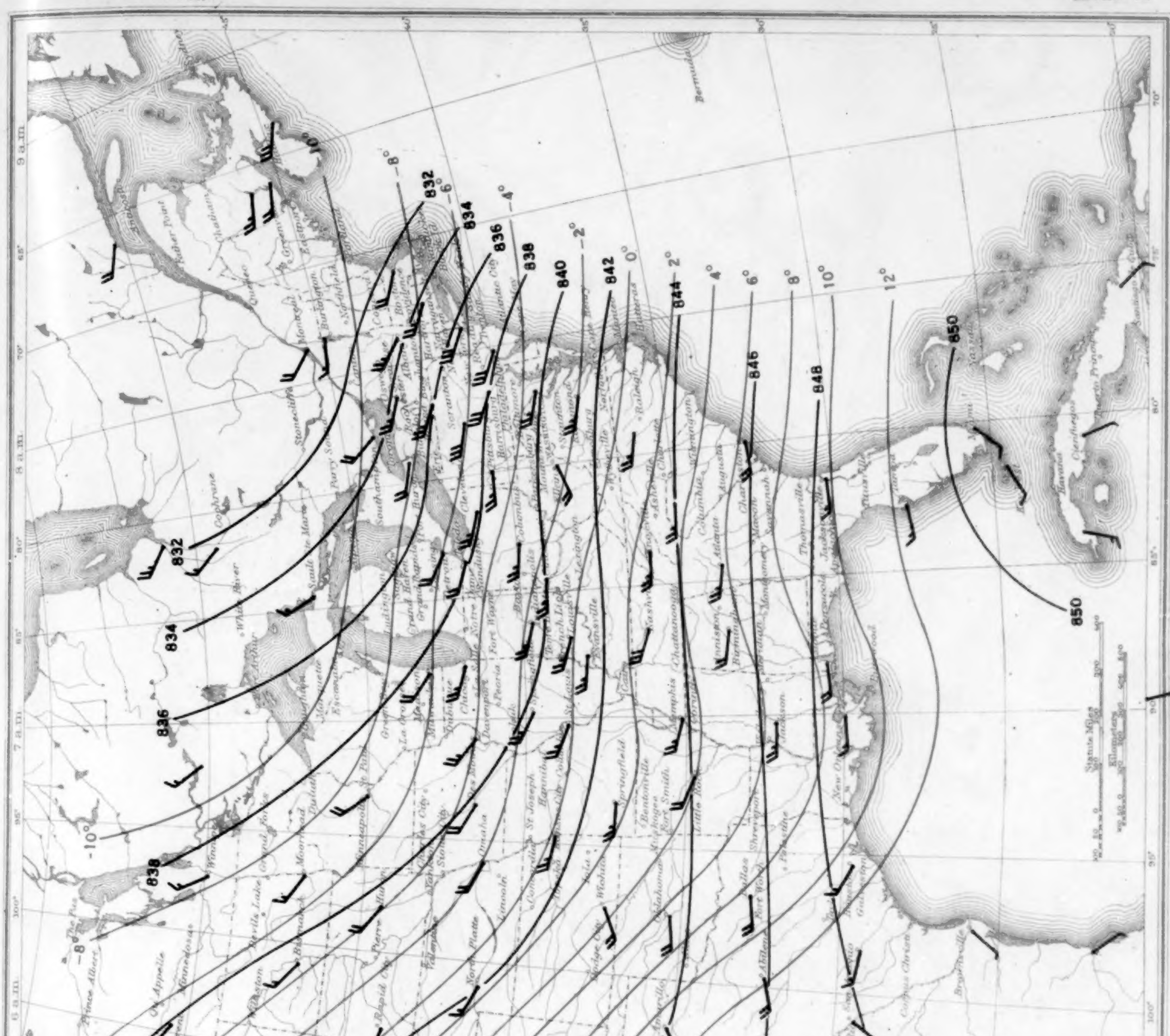


Chart VII. Total Snowfall, Inches, March 1940. (Inset) Depth of Snow on the Ground at 7:30 p.m., Monday, March 25, 1940

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) March 1940

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) March 1940



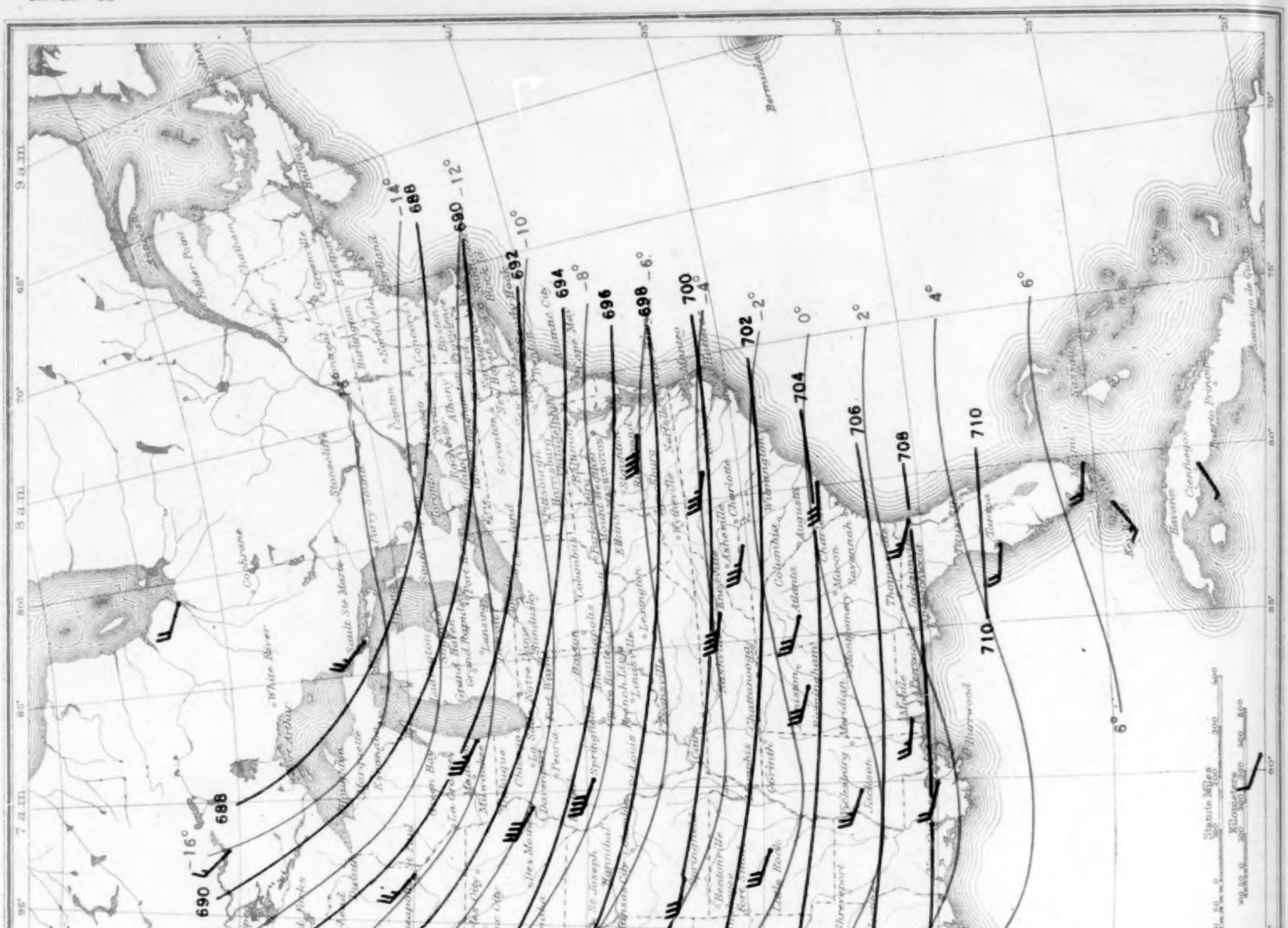


Chart IX. Isobars (mb) Isotherms (°C.) and Resultant Winds for 3,000 Meters (m. s. l.) March 1940

Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) March 1940

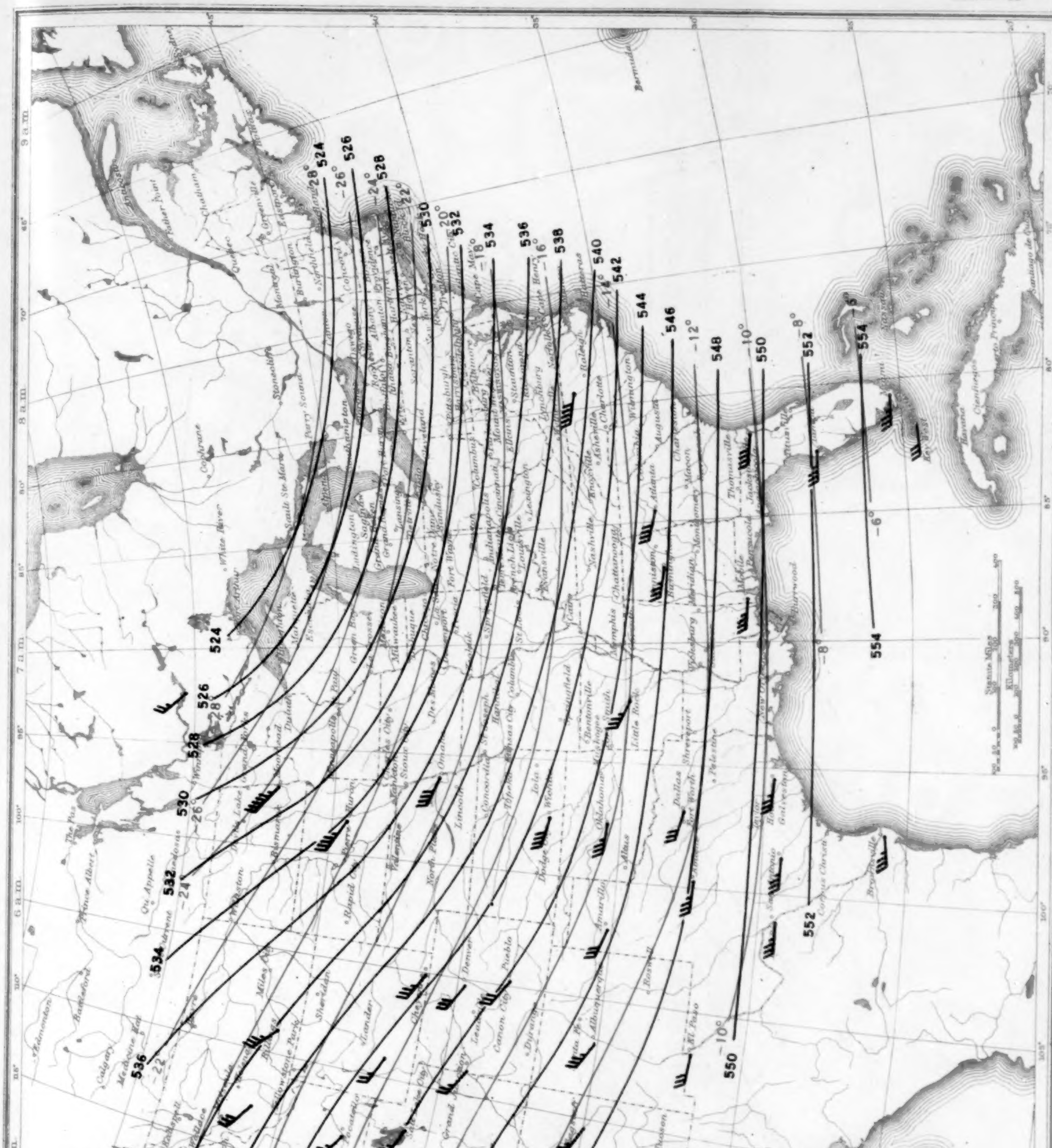


Chart XI. Isobars (mb) Isotherms (°C.) and Resultant Winds for 10,000 Meters (m. s. l.) March 1940

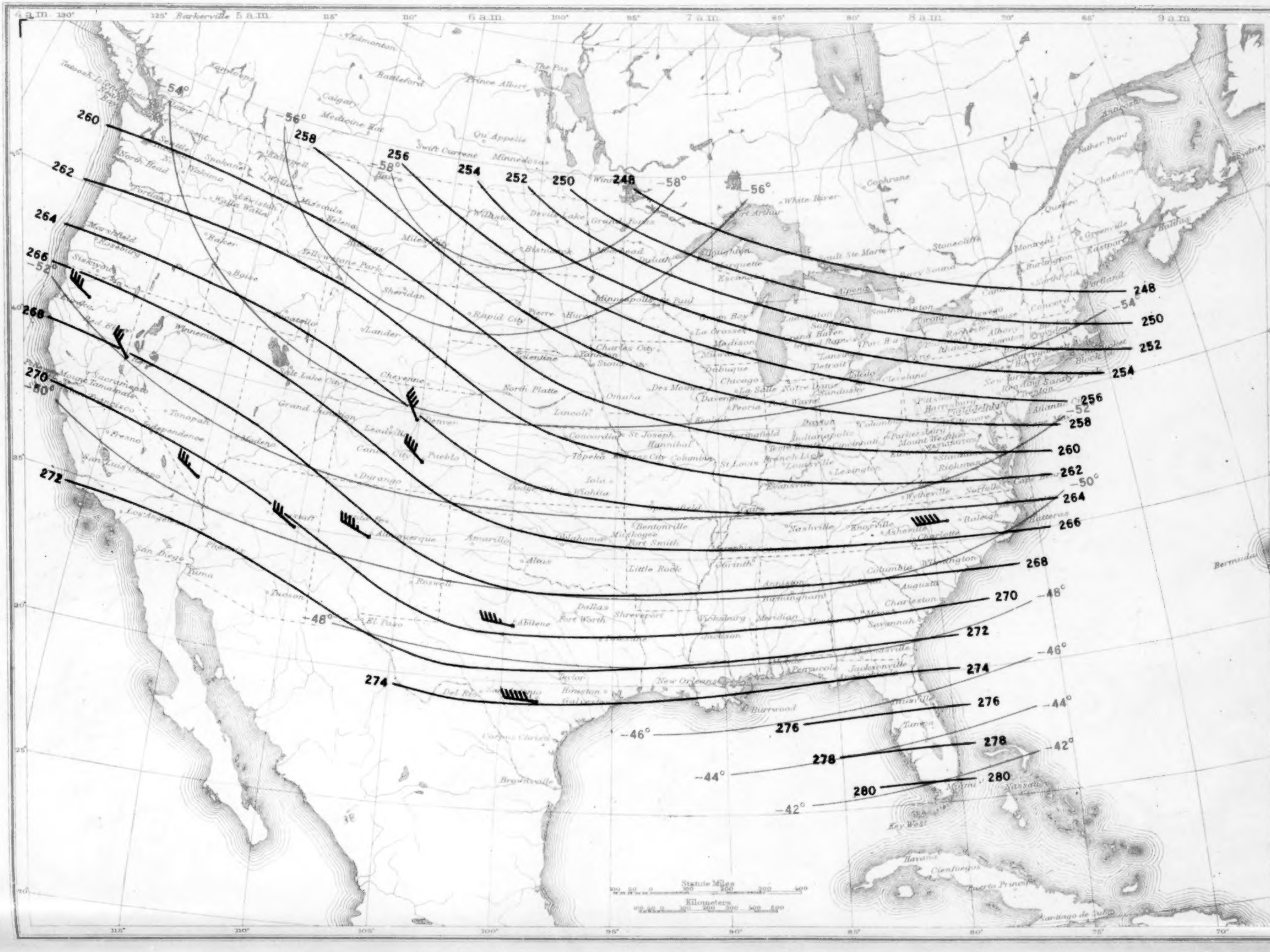


Chart XII. Mean Isentropic Chart, March 1940 (Potential Temperature 298° A.)

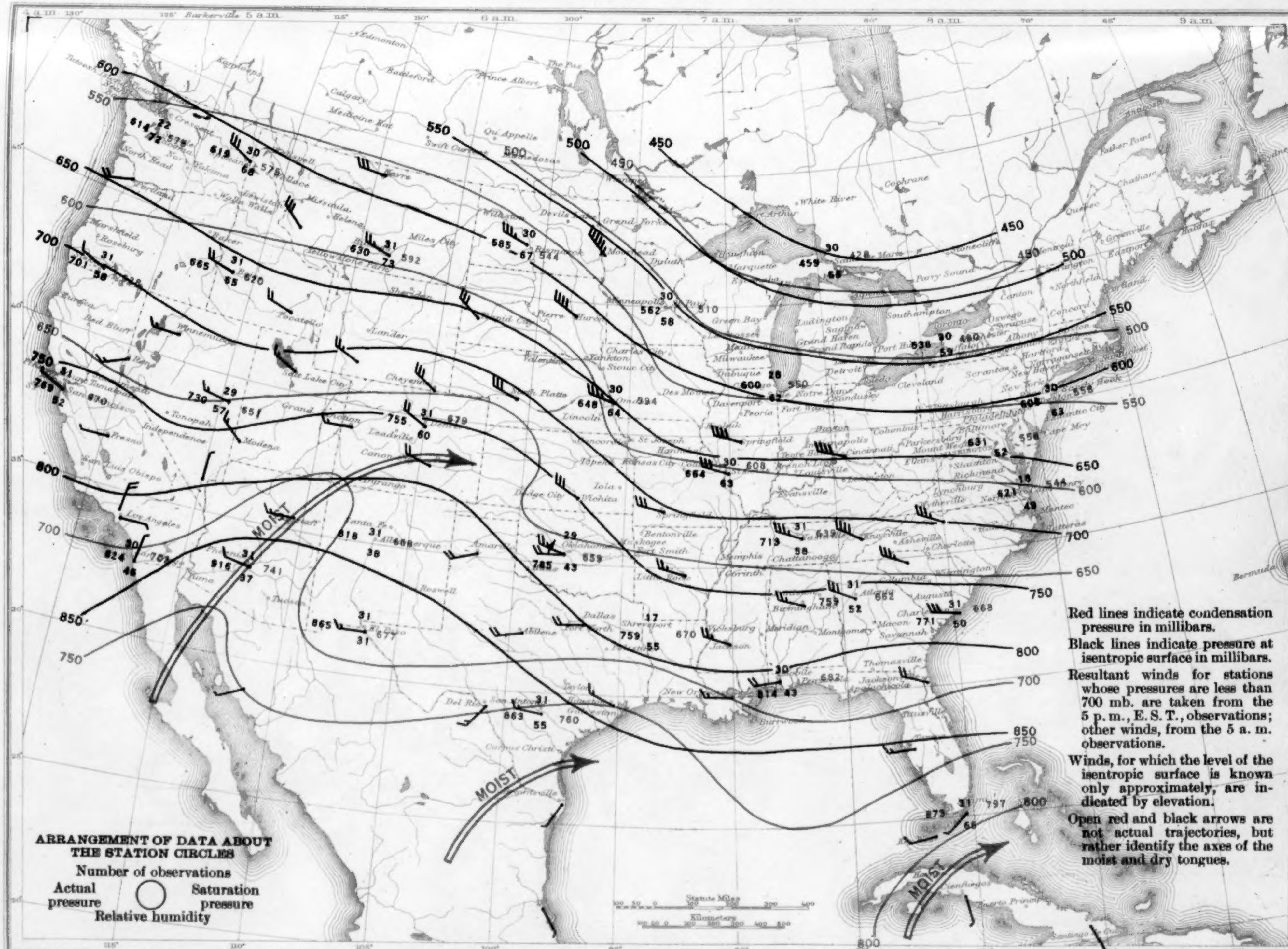


Chart XIII. Mean Tropopause Data, Altitude (km.) (m. s. l.) Temperature (°C.) March 1940

(Data from table 4)

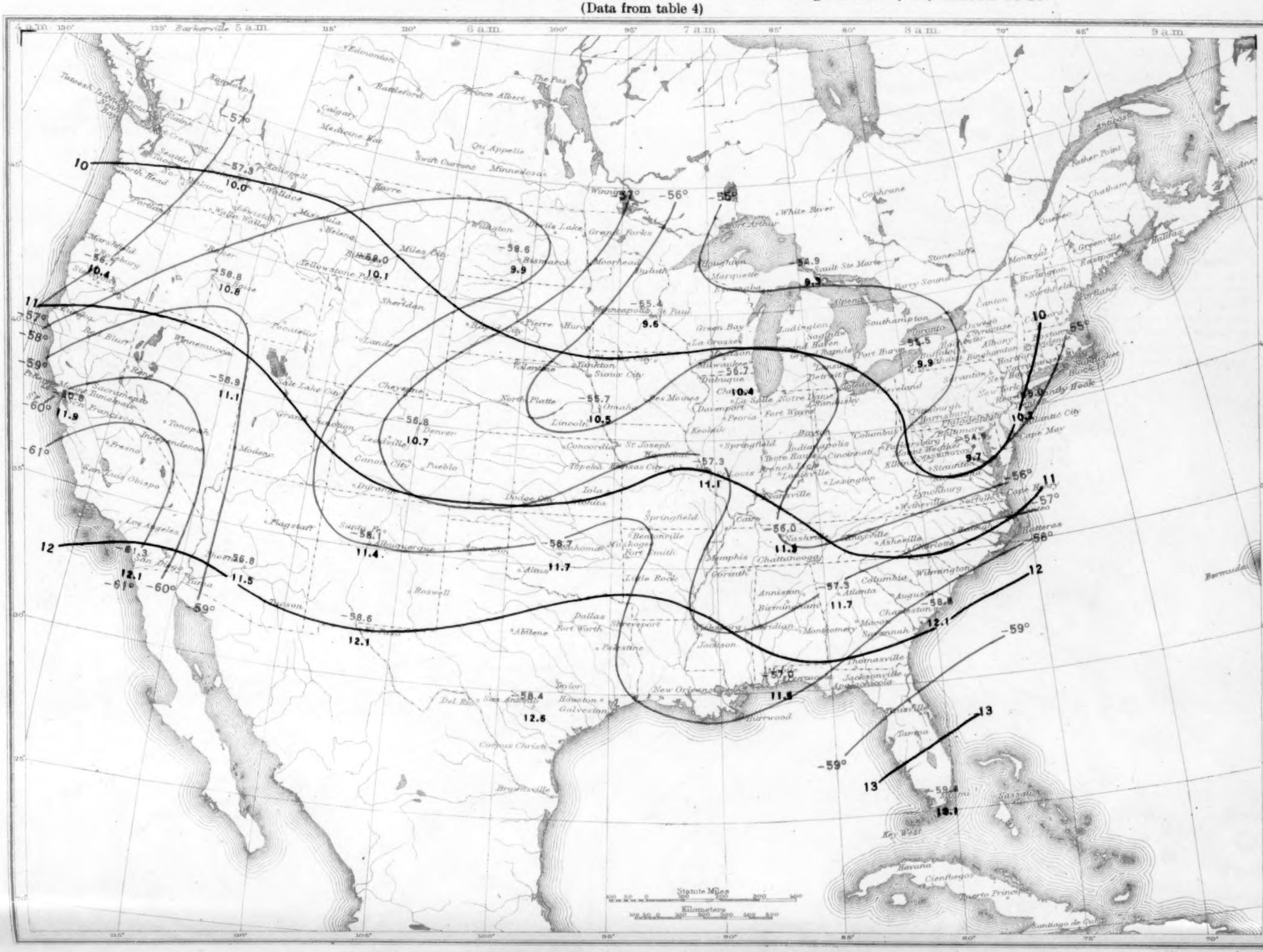


Chart XIV. Weather Map of North Atlantic Ocean, March 9, 1940

Chart XIV. Weather Map of North Atlantic Ocean, March 9, 1940
(Plotted from the Weather Bureau Northern Hemisphere Chart)